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PAGE 58

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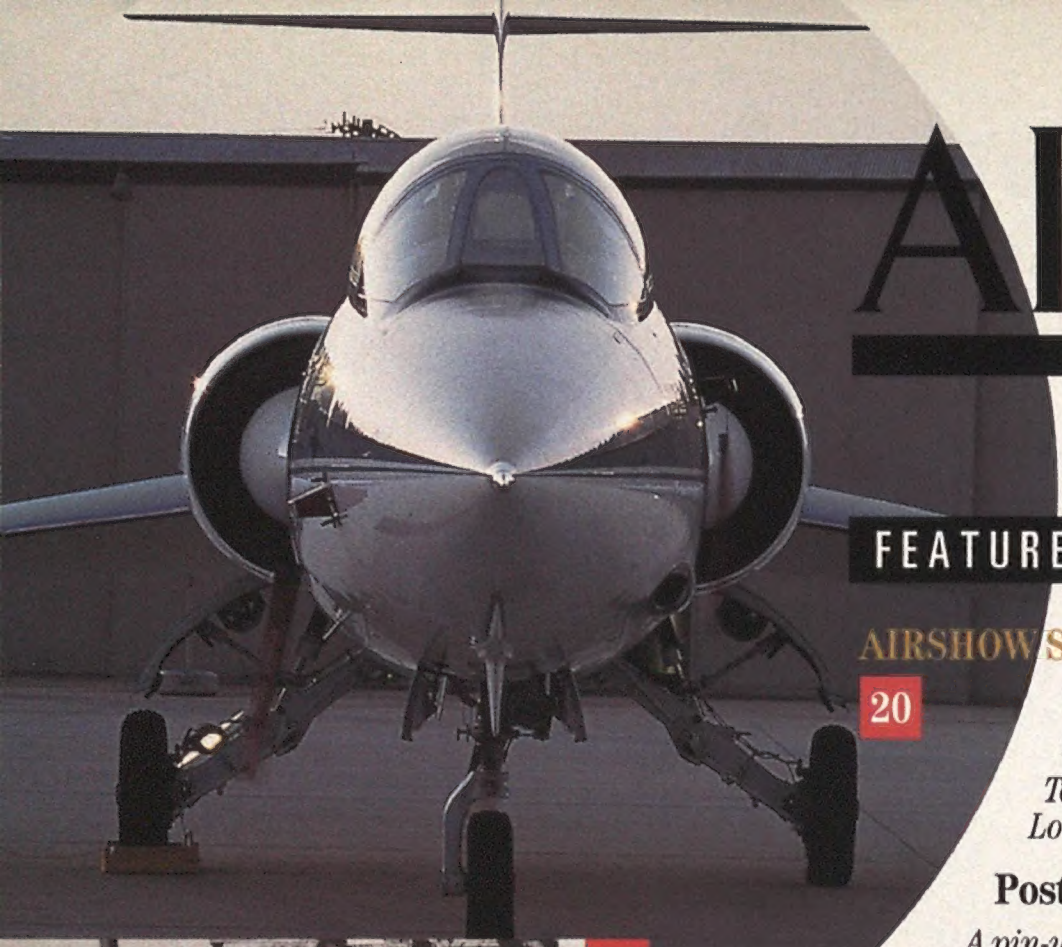

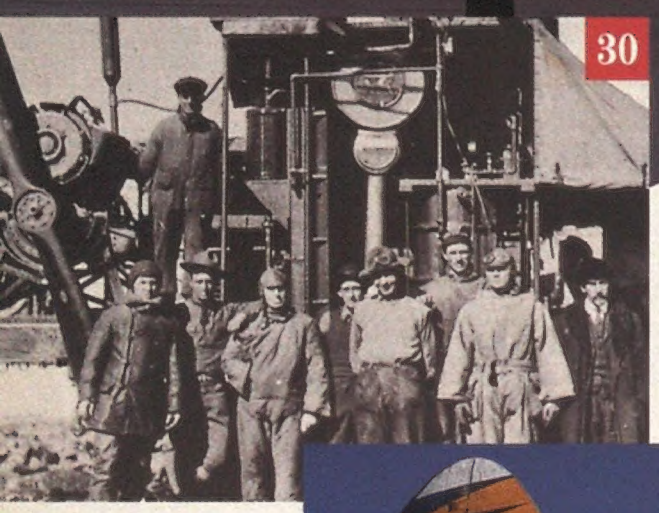

Cover: As Chad Slattery's sunny photograph in El Mirage, California, suggests, the future is bright for the RQ-1 Predator reconnaissance craft.

AIR&SPACE

Smithsonian

April/May 2001
Volume 16 • Number 1

FEATURES

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That's Entertainment

In this issue we celebrate the return of the airshow season, which kicks off every spring and runs through November. Airshows showcase aircraft and pilots while providing excitement and education for millions of people. The International Council of Airshows estimates that up to 18 million people will attend airshows throughout North America this year—a staggering figure that reveals how appealing it is for many people to sit back and enjoy this unique form of entertainment.

In this issue, you'll read about how the Lockheed F-104 has become one of the hottest additions to the airshow circuit. The Museum's F-104—a rare example of a Starfighter that saw service with NASA—was not acquired because of its airshow role (although we can now add that to the type's list of accomplishments), but our collection does include several aircraft that represent the best of what airshows have offered for nearly 100 years. Some of these—the Curtiss Pusher, the Blériot XI, and the Wright *Vin Fiz*—flew at exhibitions before World War I. The Golden Age of flight is represented by Al Williams' Curtiss Gulfhawk I and Grumman Gulfhawk II, Woody Edmondson's Monocoupe 110, and Bevo Howard's Bücker Bü 113 Jungmeister, first flown in the 1930s in Germany by European aerobatic pilots.

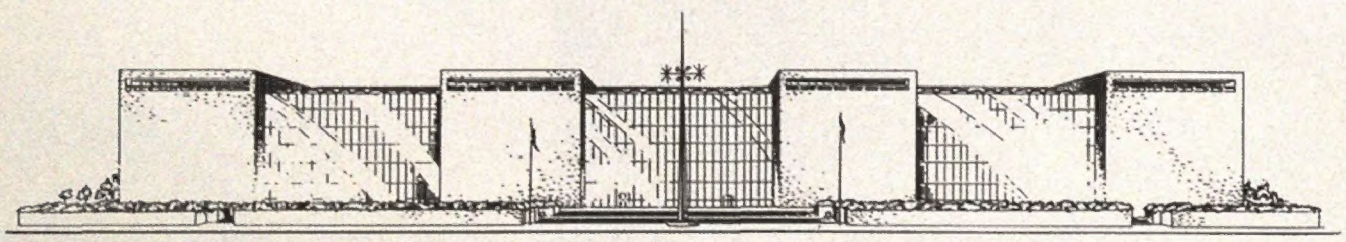
Betty Skelton performed at airshows in the late 1940s and early 1950s in her Pitts S-1C *Little Stinker* (and also won the Feminine Aerobatic Championship in it for three years running), and today, you'll see a Pitts at just about every airshow around the country. Art Scholl's de Havilland DHC-1A Chipmunk thrilled airshow audiences and served as an aerial platform for motion picture and TV cameras. Patty Wagstaff flew her Extra 260 in countless airshows while also competing; she became the first woman to win the title of National Aerobatic Champion. Each of these aircraft—and the story of its legendary pilot—has a place in our collection.

Three recent acquisitions add to the collection's legacy of airshow artifacts: aerobatic champion Leo Loudenslager's Laser 200, the Rockwell Shrike Commander flown by Bob Hoover, and the *Pepsi Skywriter*, a Travel Air D4D that has been writing "PEPSI" in smoke since 1931. We are pleased to be able to preserve these historic aircraft, which have delighted the public for many years.

Only the Curtiss Pusher, the Blériot XI, and Patty Wagstaff's Extra 260 are on display right now, but they will be joined this fall by a temporary exhibit of the Pitts S-1C *Little Stinker* and the Laser 200. The other artifacts in this magnificent collection will be displayed so that they appear to "fly" at the Steven F. Udvar-Hazy Center, now under construction at Dulles Airport.

Our curators attend airshows to identify aircraft that might be suitable additions to our collection. Recently, the Museum has also exhibited at airshows to let the public know about the Udvar-Hazy Center. This summer we'll attend the Experimental Aircraft Association's AirVenture in Oshkosh, Wisconsin, and we hope you'll stop by and visit us. Throughout the summer and fall, if you attend any of the airshows around the country, you may see a performance by the next addition to our collection.

—J.R. Dailey is the director of the National Air and Space Museum.



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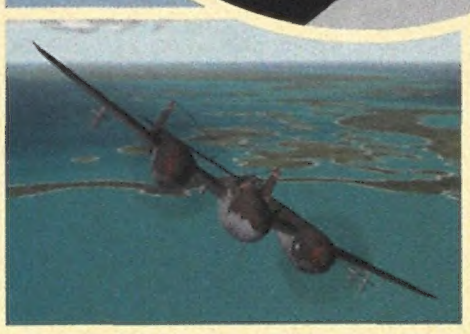

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LETTERS

Experiencing Conversion

When people insist they grew up with the conventional system and are familiar with it, I ask them: "How many milliliters are in a liter?" and then "How many ounces are in a gallon?" ("Metric Mayhem," Commentary, Feb./Mar. 2001). While almost everyone can answer the first question, the second leaves them counting on their fingers and coming up with a variety of wrong answers. While I'm all in favor of converting to metric, during the period the airlines are in transition, I think I'll take Amtrak.

—F. Barry Mulligan
Atlanta, Georgia

When the author referred to the Canadian airliner that nearly ran out of fuel after having been fueled by a U.S. ground crew, I assume he meant the July 23, 1983 incident in which Air Canada Flight 143 was flying between Montreal and Edmonton, Alberta. The plane was a brand-new Boeing 767. The ground crew members who fueled it were in Montreal, so presumably they were Canadian. This airplane was one of Air Canada's first to be fueled using the metric system—i.e., kilograms versus pounds. The 767 was flying over Red Lake, Ontario, at 41,000 feet (whatever in meters) when the engines didn't "almost" shut down—they did shut down. Suddenly Captain Bob Pearson and his crew had no engines, no instruments (all CRT displays), no hydraulic boost on the controls—basically just a 132-ton glider with 29 minutes of glide time. They landed successfully at a closed Air Force base, but nearly collided with spectators watching an auto race there. The incident was described in great detail in the book *Free Fall* by William and Marilyn Mona Hoeffer and also in a very-well-done television movie.

—Jim Hyslop
Richfield, Minnesota

Michael Milstein's crotchety language glosses over what may be the single greatest barrier to converting to the metric system in this country: entrenchment. To name one example (and there are many), in virtually every building in this country, including houses and apartments, cover plates are held in place over the electrical switches and outlets with #6-32 UNC screws, which have a 0.138-inch nominal diameter and 32 threads per inch. There is no metric screw thread that fits satisfactorily into the #6-32 threaded holes in the electrical wiring boxes. As long as people want to redecorate with new cover plates, hardware stores must continue to sell #6-32 screws. Either that, or redecorating in the future will mean ripping out the boxes and replacing them with new ones that use metric screw threads.
For this and many other reasons, adopting metric units in this country would in reality not be a conversion, but the addition of a second system, because there is no practical way to eliminate the millions of applications for #6-32 screws and other inch-based hardware items.

—David H. Kirkpatrick
Rochester, New York

I work in the aerospace optics industry. Nearly all of our scientific calculations are in metric units, as is quite a bit of our hardware. Suppliers, even local mom-and-pop machine shops, have no difficulty producing metric components; the United States is reasonably familiar with the metric system. You do a disservice to the community by assuming that we cannot understand a 100-kilometer orbit about an asteroid, but a 62.14-mile orbit is perfectly clear.

—Dan Hofstadter
Tucson, Arizona

On Shaky Ground

A little-known development in the intense Electra flutter investigation highlights the frequent correlation of widely disparate technologies and the insular nature of scientific progress ("The Hammer," Feb./Mar. 2001). In the mid-1950s, the emerging helicopter introduced a frightening phenomenon called ground resonance. A perfectly sound production helicopter firmly supported on its landing gear with the rotor turning at or near flight rpm would suddenly initiate a "tramping" on the gear and then, almost immediately, completely disintegrate. The Sikorsky company, which was leading the pack in developing the helicopter, quickly gathered the most data on these ground-based disasters and thus shouldered the lion's share of corrective understanding and action. The company established that the lead/lag pivots on the rotor blades, the pylon elastic stiffness, and the elastic components of the landing gear, including the tire and shock struts, all working together as a single structural entity, had an unfortunate resonant frequency near the rotor

operating rpm. The engineers were able to show that a fearless pilot, entering the resonant phase, could save the day by pulling up the collective pitch control and unloading the landing gear (i.e., getting airborne). Lowering the resonant frequency and adding damping offered a permanent solution.

As an engineer at the Kaman Aircraft Corporation, a helicopter manufacturer in direct competition with Sikorsky, I had a conversation at the time with a Sikorsky engineer—we often discussed engineering problems—who said that broad similarities between helicopter ground resonance and the Electra puzzle caused Sikorsky to urge Lockheed people to shift their sights from traditional failure patterns to what was a new thought process for the fixed-wing people. Today, all of us in the helicopter development business, with the apprehension borne of substantial ignorance, approach initial ground whirl testing of each new helicopter with tremulous respect for the demon of ground resonance.

—John O. Emmerson
West Granbury, Connecticut

Inverted Hawker, Inverted

My son and I believe that the picture of the Hawker Hurricane on page 82 would have created more of an impact had it not been printed inverted ("Rescue Mission," Reviews & Previews, Feb./Mar. 2001). We turned over the magazine and decided that the inverted-rolling-to-level Hurricane would be a better shot.

—Richard Blanchard
Phoenix, Arizona

Editors' reply: The clouds evidently threw us for a loop. We like it right side up—er, upside down—too.

Swiss Surprise

In addition to being a fine article about a little-known aspect of the Swiss air force ("Don't Mess With Switzerland," Feb./Mar. 2001), the photography by Katsuhiko Tokunaga is nothing less than breathtaking. Beginning with the spectacular cover photo of formation flying over the Alps, I was captivated. As a photographer, graphic designer, and private pilot, I can appreciate what he has accomplished. Not only are the photos dramatic, they are composed with an artist's sensibilities and a craftsman's impeccable touch—while in aerobatic circumstances! Kudos to Tokunaga.

—Karl H. Steinbrenner
New York, New York

Your article brought back fond memories of my basic training in Payerne and the subsequent yearly services in Duebendorf and Ambri Piotta, near the south end of the St. Gotthard tunnel. In 1950 and 1951 I was assigned to Flight Company 12 as a weapons specialist on the Morane D3800. The cave at Ambri Piotta was under construction and we marveled that in years to come we could actually sleep in beds—underground, rather than on our straw-filled mattresses in cramped prefab wooden barracks. The enormous sliding doors protecting the entrance to the cave still lacked motors for opening and closing, and we had to crank, with six men on each side, for about 20 minutes to fully

open or close them.

In the late 1960s my wife and I took our three kids to Switzerland for the first time. Approaching the Ambri Piotta air strip, they all thought I was kidding when I told them that there, behind the trees, was a huge cave with 12 fighter jets. Now I finally have proof that Switzerland *does* have an air force!

—Fred Schiess
Granada Hills, California

Wow! The Swiss must have a nuclear-powered aircraft carrier on Lake Geneve—all the jets have tail hooks!

—Donald Eggensperger
Grand Junction, Colorado

Jürg Nussbaum, head of information of the Swiss air force, explains: At the time of procurement, all F-5E Tiger aircraft, including those procured by the Swiss air force, were equipped with tail hooks as standard parts. The tail hooks were not used in Switzerland, and consequently all tail hook systems were deactivated. But with the introduction of the F/A-18, arrester wires were installed on the runways of our air bases and the F-5E's tail hook systems were reactivated, as emergency landings with arrester wires are safer.

Terra Very Cognita

Thanks to Tony Reichhardt for compiling the beautiful, stunningly detailed satellite photographs and the data they reveal ("Terra Cognita," Feb./Mar. 2001). What we found astounding was that, as we carefully studied the Landsat 7 image of Cape Canaveral, we were able to pick out actual roads with which we were familiar, then ponds—then eventually our pond and house! I suppose I will never be able to hang dainties out on the laundry line again.

—Kim Smith
Merritt Island, Florida

Foreign Intervention

As a professional pilot and attorney at law, I found the points raised by Kenneth P. Quinn ("Why Airline Crashes Aren't Criminal," Commentary, Dec. 2000/Jan. 2001) well made. Despite the prosecutors' actions against company personnel in the Sabre Tech case, flight crew members like myself who have the good fortune to operate mostly in U.S. airspace can take some comfort in the fact that we at the controls are seldom criminally prosecuted in fatal air accidents in this country. Those of us who take our birds overseas need to heed the fact that this is not so elsewhere. Take Taiwan, for example: In the late 1960s the government brought the U.S. crew of a Civil Air Transport Boeing 727 up on manslaughter charges after a fatal accident that was caused largely by errors in poorly installed and sited ILS (instrument landing system) ground equipment. The Taiwanese are attempting to behave the same way after the recent Singapore Airlines fatal accident in Taipei. After the trauma and anguish that the surviving Singapore Airlines crew endured, the Taiwanese detained the crew members in Taiwan while attempting to trump up criminal charges against them.

One can see a pattern emerging here: The priority of top managers is to avoid being held accountable, thus losing face. Instead, they'll find an expendable scapegoat to take the fall, thus drawing attention away from the incompetence of local departments under their responsibility in installing ILSs, marking runways as taxiways, and so on.

—David S. Tan
Executive Jet Netjets
Columbus, Ohio

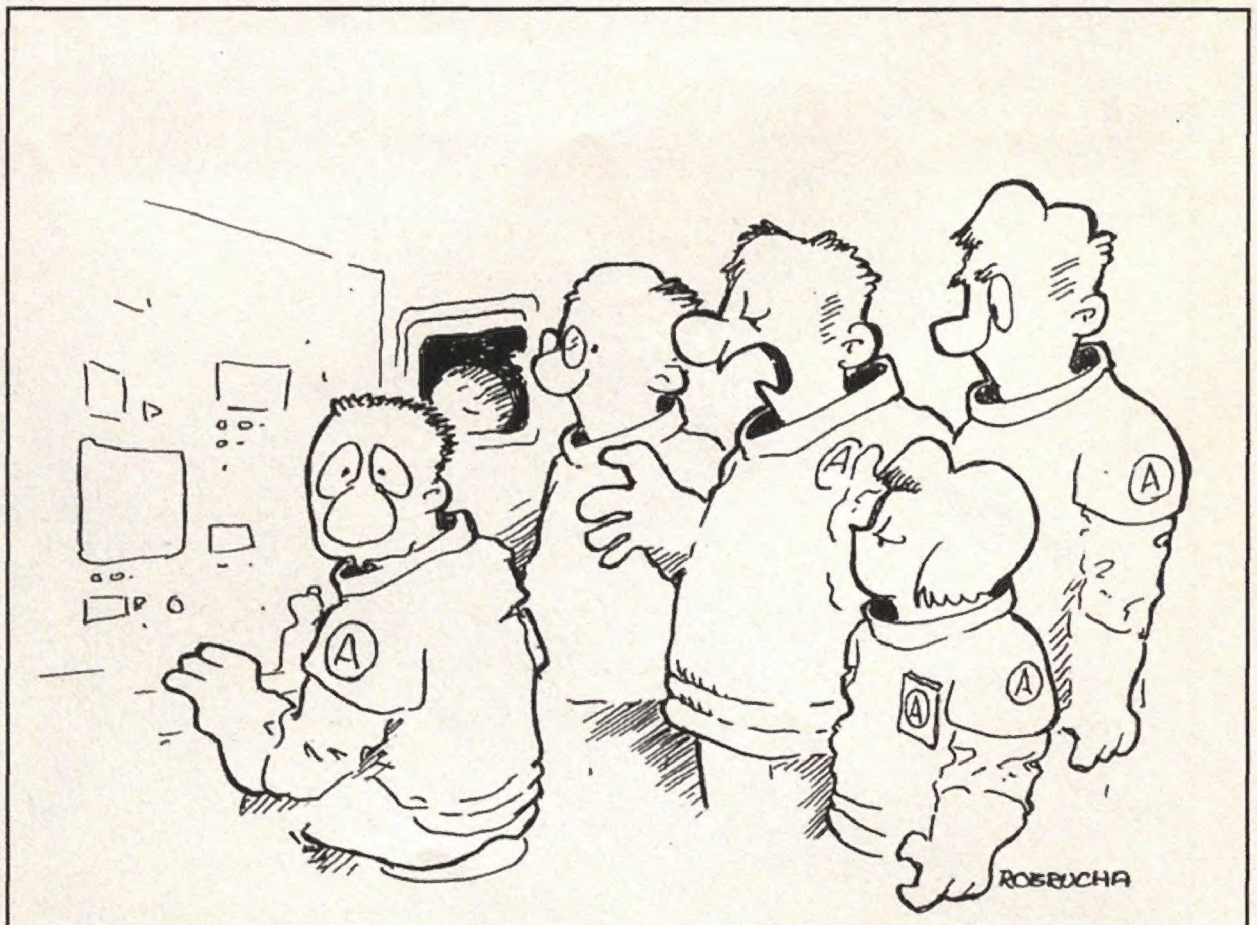
Secret Sub

Yours was the first mention of that plane-carrying submarine that I have ever seen in print ("The Japanese Connection," In the Museum, Dec. 2000/Jan. 2001). I served in the Navy in World War II. A few weeks after the end of the war, while I was stationed in Guam, I was fortunate enough to get a tour of one of the subs. They had the big watertight door open, and the plane was sitting on the catapult. Lots of my friends thought I was telling a story. Now I have proof!

—Robert Harrison
Beaverton, Oregon

Live From Space

In his review, D.C. Agle refutes several statements made by Gordon Cooper, including the claim that "Cooper was the first to carry a TV camera into space" ("Leap of Faith," Reviews and Previews, Dec. 2000/Jan. 2001). Though it may take a leap of faith to believe the other claims Cooper makes in his book, it is true that the sixth American to fly into space carried the honor of being in the first U.S. manned spacecraft to transmit live television during a mission.



"Bad news, Schmedley. You've been voted off the shuttle."

Most people would argue that Apollo 7 was the first manned U.S. spaceflight to broadcast live television from space, but this is not true. Cooper carried a small black-and-white television camera inside his Mercury spacecraft, *Faith 7*. The eight-pound camera was placed on the spacecraft to determine the quality and usefulness of television for ground monitoring of both the astronaut and his instruments. During Cooper's historic 1963 flight, the camera not only beamed slow-scan television images showing Cooper's face inside his space helmet, but as part of the experiment, Cooper aimed the camera out the spacecraft's window to beam live images of Earth from orbit to ground tracking stations.

—Glen E. Swanson
Historian, NASA/Johnson Space Center
Houston, Texas

Risky Business

"Test Drivers" (Dec. 2000/Jan. 2001) does an excellent job showcasing the dangers of the profession of test piloting aircraft. However, when the author referred to Cirrus Design Corporation, he made two errors. On page 47, the article says, "relative newcomer Cirrus Design Corporation has experienced several crashes, resulting in the deaths of three test pilots." We have had two accidents and we have lost two test pilots. Nearly all aircraft manufacturing companies have had fatal airplane crashes during flight tests. To single out Canadair and Cirrus Design does not tell the whole story.

—Chris Maddy
Cirrus Design Corporation
Duluth, Minnesota

Correction

Dec. 2000/Jan. 2001 "And They're Off!," Moments & Milestones. The photographer of the X-35's first flight was Tom Harvey.

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Changing the Guiding Light

When you want to change a burned-out light bulb in Manhattan, usually all you need to do is put in a call to your super. (Okay, make that a few calls.) But what about the aviation beacon on top of the Empire State Building, a flashing red light that wards off low-flying aircraft? When that burns out, you need to phone someone three states away. Building engineers consider Tom Silliman, who runs Electronics Research, Inc., based in tiny Chandler, Indiana, one of the best "antenna men" in the business. "I've been up there probably a hundred times," the laconic 56-year-old Silliman says. When the call comes, Silliman has just two days to get the job done—weather or not. It's been this way since the early 1970s, when he made his first ascent.

"You know, the lights are required more for helicopters than jets," he says. "Half the time you fly into Manhattan, you fly along the Hudson River. If you get near an aviation light you're in trouble." Mishaps have occurred: In 1945 a fogbound B-25 slammed into the building's 79th floor. Eleven people in the building perished, along with five in the airplane. "That was kind of a bad deal," says Silliman.

Silliman rides the elevator to the 80th floor, transfers to another elevator that goes to the 86th floor, and then, to get to the 102nd floor, takes a third car, which "they only operate for special parties or me," he says. He walks up two flights, to the 104th floor, and enters the High Radiation Area. Here, 17 million watts of power flow to the antennas of the five television and 16 radio stations broadcasting from the building's antennas. And here, the engineers douse the power. Once the power's down, Silliman's stopwatch starts ticking: The stations can't make a dime when they're off the air.

Wearing warm, heavy clothing, he climbs out of a porthole with a bag of tools and two aviation light bulbs. He's just 204 feet below the beacon—of course, that's all vertical. For 117 feet he climbs up a ladder enclosed by wire mesh; the last 87 feet he scampers up a precarious eight-inch-wide antenna with four-inch bolts welded to the sides for foot- and hand-holds. Once he's at the top, at an altitude of 1,454 feet and with the wind sometimes gusting to 50 mph, he latches on with his climbing belt and takes maybe 10 minutes to change the 10-inch, 625-watt bulbs.

Silliman can log a round trip in just 45 minutes. "No, I never drop things off the Empire State Building," he says. "It takes a $20 million insurance policy to work up there, so I tape my bags up." Once, though, the wind blew so hard his bag started whipping around and smashed a bulb. "I only changed one bulb that night," he adds.

Also under Silliman's care are the Prudential Building in Boston, the Hancock Building in Chicago, and the Tower of the Americas in San Antonio, to list but a few. "Wherever there's radio antennas on buildings, I get the job," Silliman explains. "A lot of people think it's amazing that someone can go up and do it, but I don't consider myself brave. I do it for a living."

—Phil Scott

The Top Prop-Head

Airshow pilots love their fans, those beaming faces on the other side of the flightline, arms waving, cameras snapping, kisses blown from fingertips. The fans are as much a part of the show as the pilots. They bring the energy and excitement that turn airport ramps into a flight museum, a marketplace, and a bustling airshow arena.

Last year the International Council of Airshows decided to turn its spotlight on the crowd behind the ropes. ICAS would find its greatest fans and crown one each winter as ICAS Airshow Fan of the Year. "It's fairly common in our society for the fans and the press to recognize the entertainers and the athletes," says ICAS president John Cudahy, "but what is unique about the airshow industry is that the performers know that it is because of the spectators that they get to do what

they love. So with this we've put the spectator at the forefront."

Forty people stepped into that spotlight, either nudged by friends or inspired on their own, convinced they deserved to be the Year 2000 Airshow Fan, but ICAS performers voted for Perry Bales, 68, of Oakland, California. He went gaga for airplanes 60 years ago, but couldn't learn to fly—first his father forbid it, then his eyesight betrayed him—so he joined the Navy as an aircraft metalsmith. That put his hands on airplanes and gave him a 20-year ticket to naval airshows. "Since high school I've seen the Blues [Blue Angels] fly everything but the F6 Hellcat," he says. "I was even in Olathe, Kansas, in 1954, the first time the Blues and Thunderbirds flew a show together."


ICAS

Airshow Fan of the Year Perry Bales wins the support of airshow pilot Julie Clark and her cardboard twin.

Though his second career, with Volvo auto parts, separated him from his passion, an airshow 15 years ago brought him back. When he saw Bobby Bishop zip by in the Coors Silver Bullet, he was hooked again. Now he drives to 20 airshows a year. "Perry's here; there must be an airshow," people say when they see him in his black jumpsuit with its 20 patches, the ball cap studded with a hundred aviation pins, and the converted golf cart. Topped by the seat from his wife's Exercycle, it carries his three cameras and refreshments. "When I step out on that ramp, 40 of my 68 years just slip away," he says. His car license plate frames say "Airshow Fan Ambassador" and "I Brake for Airshows."

His reward for winning included a plaque; a leather jacket with his name, the ICAS logo, and his new title; and a trip to Las Vegas for the ICAS annual convention, where he collected a bagful of new pins and patches and spent a day among the airshow stars. At the evening banquet, when he received his award and accepted it on behalf of fans the world over, the people he admired most clapped, cheered, and gave him a standing ovation.

Years ago, Bales had calling cards printed: "World's Greatest Airshow Fan (self appointed)." Now it's official.

—Debbie Gary

UPDATE

The Loneliness of the Long-Distance Drone

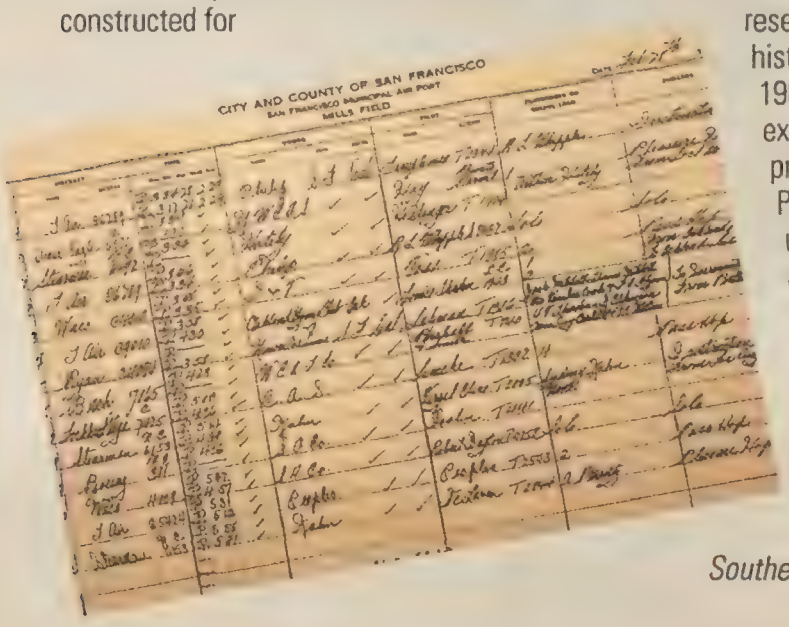
The Insitu Group, which in 1998 made the first transatlantic flight by a robotic aircraft ("Breaking the Sonde Barrier," Oct./Nov. 1999), is setting its sights on the Pacific. Insitu and the University of Washington are planning to fly a new miniature aircraft, Seascan, 4,700 miles entirely over water, from Asia to Washington State, over the course of 48 hours this fall. Insitu is promoting Seascan as a tool not only for offshore weather observation, as was the Aerosonde, but for environmental monitoring and ship-based reconnaissance as well.

COLLECTIONS

San Francisco Airport Commission Aviation Library and Louis A. Turpen Aviation Museum

San Francisco International Airport
San Francisco, California
phone (650) 652-2772
10 a.m.–4:40 p.m., Mon.–Fri.
Closed on holidays
www.sfoArts.org

Mills Field operated on a corner of what is today San Francisco International Airport from 1927 to 1931 and hosted aviation luminaries like Charles Lindbergh, Amelia Earhart, Paul Mantz, and Louise Thaden. In 1937, the field was renamed San Francisco Airport, and a small terminal was constructed for passengers of Transcontinental & Western Air and United Air Lines. Pan American Airways relocated from nearby Treasure Island to the airport's seaplane harbor after the Navy expanded its wartime operations at Treasure Island, squeezing the airline off. The airline transitioned to land-based operations; its last scheduled flying boat landed on the bay in April 1946.



With the growth of air travel, the airport was remodeled many times, and in 1994, as airport commissioners planned a new international terminal, they set about re-creating the 1937 waiting room as an aviation museum and research center documenting the site's rich history, named for the airport director from 1981 to 1995. Thousands of artifacts are exhibited on a rotating basis. Focused primarily on commercial aviation in the Pacific, the collection includes air crew uniforms, in-flight meal service wares, aircraft models of the era, and posters. First flight airmail covers trace Pan Am's progress across the Pacific to China. Airport registers from the 1920s provide records of flight operations detailing air crew, passengers, purpose, and pilot comments. Scale models of the United DC-3 *City of San Francisco* and the Fokker *Southern Cross*, which in 1928 flew from nearby Oakland to Brisbane, Australia, are suspended from the exposed arched ceiling. The Art Deco terminal doors through which the passengers arrived are displayed with period photographs.

The library contains some 6,000 books on civil, commercial, and military aviation, as well as a multitude of photographs, maps and charts, and architectural design drawings. The library also houses 2,000 aviation magazines spanning a hundred years, and maintains subscriptions to 150 periodicals.

—Rafe Tomsett

Elegy in the High Desert

"I came in about three years ago," says William Lange, a former Rotary Rocket employee. "That was just after the beginning of the company. Now I'm here for the end." Rotary Rocket, formed to provide the ever-elusive cheap ride to orbit, has failed (see "Rockets for the Rest of Us," Feb./Mar. 1998).

Lange and some 70 others had not only signed on as Rotary employees, they bought into the concept that a 400,000-pound missile with a propeller on its nose and a spinning rocket engine in its aft end was going to make cheap access to space a reality.

The plan was to build Roton reusable rockets that would serve an estimated $30 billion telecommunications satellite market at a fraction of the cost of existing expendable rockets. Rotary opened a 45,000-square-foot Roton manufacturing and flight operations facility at Mojave Airport in California, raised $33 million from investors, and claimed they'd be flying into space by 2000. Then things started unraveling.

"Well, the satellite phone company Iridium went belly up," says former Rotary consultant Jim Ransom. "So did [Globalstar] and a couple others. Essentially, the commercial satellite market tanked."

CHAD SLATTERY

Ransom admits that even if the commercial market remained viable, Rotary Rocket had a long, tough road ahead before making it to orbit. But, he adds, for all the company's bad luck, technical hurdles, and fiscal missteps, at least they got airborne.

"We flew our Roton test vehicle four times in 1999," he says. "Its maximum altitude was only 75 feet, but it flew. Go 30 miles south of here and ask Lockheed Martin how many times they have flown their X-33 with 30 times our budget. The answer is zero." (Early in March, NASA announced it would no longer fund the X-33 reusable launch vehicle or Orbital Sciences' X-34.)

Here in the Rotary Rocket Assembly Building, the Roton test vehicle is little more than a backdrop to the proceedings. After the auction, it will be donated to any willing aerospace museum with a yen for the unique and the budget to move it.

"To me this edifice is like a church, and it's crumbling," says Lange. "And that hurts a lot."

—D.C. Agle

Shooting Stars

Sixty professional aviation photographers voluntarily grounded themselves last February to swap slides, tips, and stories. Meeting at American Airlines' C.R. Smith Museum in Dallas, they heard presentations by Lockheed Martin's Eric Schulzinger and Denny Lombard (photographing classified aircraft), Paul Bowen (corporate jets), George Hall (airliners), Katsuhiko Tokunaga (military jets), this magazine's Caroline Sheen (vintage aircraft), Erik Hildebrandt (digital applications), Jon Schneeberger (space shuttle launches), and astronaut Jay Apt (photography from orbit). Museum director Jay Miller and *Air & Space* contributing editor Chad Slattery spent a year organizing the seminar, which they hope will become an annual event. After three days of hearing photographers describe shooting from supersonic aircraft, Slattery suggested they concede bragging rights to Apt: "He's the only one here with a thousand hours in the back seat of a 17,500-mph airplane." Left to right: Eric Schulzinger, Jay Apt, Denny Lombard, Caroline Sheen, Erik Hildebrandt, Chad Slattery, George Hall, Jay Miller, Paul Bowen, Katsuhiko Tokunaga, and Jon Schneeberger.

TECH. SGT. LANCE CHEUNG / USAF

Dennis the Menace?

As the first "space tourist" concluded eight months of training for his April 30 ride aboard a Soyuz capsule to the International Space Station, NASA hoped to prevent California financier Dennis Tito from making the trip.

Yury Usachev, the commander of the second station crew, which also includes two Americans, promised to welcome the 60-year-old CEO of Santa Monica's Wilshire Associates with open arms. But Tito was getting a frostier reception as a rank amateur elsewhere. Spaceflight is still too dangerous for anyone but the best-trained crews, opponents argued. "It's kind of analogous to asking if you'd like to allow someone [who's never driven a race car] to go drive in the Indy 500," veteran shuttle commander Jim Wetherbee told reporters at Florida's Kennedy Space Center in February as he led a crew of six through a countdown rehearsal three weeks from their mission to rotate station crews.

Tito paid $20 million to fly to Russia's aging Mir space station. When the Russian government got serious about deorbiting Mir late last year, Tito lobbied for a 10-day excursion to the ISS. He would accompany two cosmonauts on a

"taxi" flight to swap Soyuz capsules (a fresh Soyuz "lifeboat" is to be delivered every six months).

Tito signed a contract with the Russian space agency Rosaviacosmos in January over the objections of a European Space Agency official, who condemned the plan as "irresponsible" and urged the United States to forbid it. Most NASA officials, acknowledging that the legalese of their partnership with Russia gives them little say in the matter, chose their words more carefully. "The Russians have the key to their spaceship, so from a physical point of view, I don't have any way of keeping the Russians from launching a rocket with somebody else in it," said Tommy Holloway, the U.S. station project chief. "On the other hand, we have a great deal of interaction and program management interface with the Russians, and I expect that we would be able to influence decisions they make along the way."

One attempt to intervene fizzled in February when the Russian delegation failed to attend a meeting of the Bilateral Crew Operations Panel to discuss Tito and ISS crew selection issues. A later meeting failed to produce a decision. Meanwhile, Space Adventures, the Arlington, Virginia company that brokered Tito's deal, says it's working to open another passenger seat on a taxi flight to the space station later this year.

—Beth Dickey

WORKS IN PROGRESS

Taking streamlined shape in the Repeat Aircraft hangar at Flabob Airport in Riverside, California, is an airworthy reproduction of Roscoe Turner's LTR-14 racer, which won the 1938 and 1939 Thompson Trophies and today awaits display at the National Air and Space Museum. The reproduction was commissioned by aviation collector Thomas Wathen, whose acquisitions include reproductions of the Schoenfeldt Firecracker 1930s racer and the 1934 de Havilland D.H.88 Comet racer *Grosvenor House*, also built by Repeat. Repeat founder Bill Turner fancies Golden Age racers: He restored Ben Howard's little monoplane *Pete*, which placed third in the 1930 Thompson, helped duplicate *Miss Los Angeles*, a 1934 Thompson racer, and reproduced the 1931 Thompson winner, the Gee Bee Model Z *City of Springfield*.

RAFE TOMSETT

The LTR-14 has also been called the Laird Turner Racer, RT-14, *Ring Free Meteor*, and *Miss Champion*, although Roscoe Turner once opined that the latter was inappropriate because "she was no lady." Bill Turner got the Lawrence W. Brown Aircraft Company plans for the original aircraft from the NASM archives, and he learned that Roscoe Turner and Matty Laird had shortened the engine mount and had added 18 inches to each wingtip, but had left behind no documentation of the redesign. Turner made a trip to the museum's Garber facility in Suitland, Maryland, to measure, photograph, and draw the aircraft. Faithful to the original, the wing spars are laminated spruce with wood ribs and mahogany aircraft plywood skins, and Repeat has installed a Pratt & Whitney R-1830 Twin Wasp engine that, tweaked to put out twice the rated 1,000 horsepower, allowed Roscoe Turner to exceed 300 mph at the 1939 Cleveland Air Races and win the $16,000 purse. With his third Thompson Trophy victory, he told photographers it was their last chance to shoot him in the Thompson, and announced his retirement. "Pylon racing is a young man's game," he said. "I am 43."

Repeat's LTR-14 will debut on the airshow circuit at the Experimental Aircraft Association's Oshkosh, Wisconsin fly-in this summer.

HEADS UP

EAA

The Experimental Aircraft Association's B-17 bomber has started its spring tour, which will take it to 10 Western states through early July, after which it will return to Oshkosh, Wisconsin.

Built in 1945 and delivered to the Army Air Forces too late to see service in World War II, *Aluminum Overcast* was put to work in mapping and spraying operations around the world until it was purchased privately in 1978. Two years later it was donated to the EAA with the provision that it keep flying.

Arrange a mission in *Aluminum Overcast* by calling the EAA's B-17 Tour Office at (800) 359-6217. Ground tours are available for a minimal fee. Funds generated will help finance ongoing restoration and maintenance of the airplane as well as others in the EAA's collection. (The schedule is subject to change.)

California
Palm Springs, April 5–9
Long Beach, April 9–12
San Diego, April 12–16
San Bernardino, April 16–19
Van Nuys, April 19–23
Santa Barbara, April 23–26
Paso Robles, April 26–30
Fresno, April 30–May 3
Visalia, May 3–7
San Jose, May 7–10
Sacramento, May 10–13
Oroville, May 21–24

Nevada
Carson City, May 18–21

Oregon
Medford, May 24–28
Eugene, May 28–31
Portland, May 31–June 5

Washington
Seattle, June 5–11
Spokane, June 11–14

Idaho
Boise, June 14–18
Idaho Falls, June 18–21

Utah
Salt Lake City, June 21–25

Colorado
Grand Junction, June 25–28
Denver, June 28–July 2
Colorado Springs, July 2

Wisconsin
Madison, July 5–9

Beautiful Goose

Affectionately nicknamed "Goose," the Grumman G-21 was the inspiration of 10 wealthy New York businessmen and aviators. Led by Wilton Lloyd-Smith, the group was seeking a replacement for the Loening Air Yacht they used to commute from their Long Island homes to their offices in Manhattan. In 1936 they approached aeronautical engineer and entrepreneur Grover Loening, who had designed the Air Yacht. Loening declined to build a new airplane for them, but he suggested that the group contact the Grumman Aircraft Engineering Corporation, for which Loening consulted and which he had helped finance. Leroy Grumman accepted and immediately went to work with designer and company co-founder William Schwendler, as well as hydrodynamicist Ralston Stalb, to build a G-21 amphibian "air yacht."

The outline of the design of the G-21 emerged quickly: It would be a stubby yet graceful aircraft. Constructed of 24ST Alclad aluminum, the Goose was an all-metal, high-wing monoplane powered by two 450-horsepower Pratt & Whitney Wasp Junior radial engines mounted on the leading edge of the high-set wings. The deep fuselage served also as a hull and was equipped with hand-cranked retractable landing gear. The cabin had room for four to six passengers and a flight crew of two. Depending on the level of comfort desired by the customer, the G-21 could be fitted with galley and lavatory. Floats were suspended beneath each wing, and a conventional cruciform tail section was installed.

On May 29, 1937, the G-21 completed its first test flight, piloted by Robert L. Hall and Bud Gillies from Grumman's Bethpage, New York factory. Flight trials went smoothly, and after a lengthening of the hull step to improve performance on water, aircraft production was readied. The performance of the G-21 was praiseworthy for its time, rivaling commercial airliners in service. With a cruising speed of 180 mph, the G-21 had a range of 800 miles.

NASM

A rugged amphibian, the Grumman G-21 served both commercial airlines and militaries alike. The U.S. Coast Guard flew the JRF version (above) as a transport and anti-submarine aircraft.

ERIC LONG

On July 3, five weeks after its maiden flight, the first G-21 to leave the factory was delivered to customers Wilton Lloyd-Smith and department store heir Marshall Field III. Soon other affluent owners were enjoying the exemplary flight characteristics and handling of the Goose: financiers Henry H. Morgan and E. Roland Harriman, C.W. Deeds of United Aircraft, Colonel McCormick of the *Chicago Tribune*, Sikorsky Aircraft test pilot Boris Sergievsky, and Britain's Lord Beaverbrook.

Orders also came in to Grumman from foreign customers. KNILM, the Dutch East Indies subsidiary of KLM, acquired two G-21s and operated them from 1940 until early 1942, when the last one was shot down by the invading Japanese. The outbreak of World War II prevented airline adoption of the Goose on a wider scale.

The Royal Canadian Air Force was the first military service to recognize the abilities of the Goose, ordering one in June 1938. This purchase was soon followed by orders from the U.S. Army and Navy, as well as the Peruvian air force and Portuguese navy. During World War II, the U.S. Army was the first to order a substantial quantity, operating 26 as OA-9s and OA-13s. The U.S. Navy and Coast Guard operated 169 Gooses, designated JRFs, in utility, transport, and anti-submarine capacities. France flew at least 15 in combat in Indochina, where several JRFs were armed with bombs and machine guns. By October 1945, when production ended, a total of 345 G-21s had been produced, and the craft were serving the air forces and navies of 11 nations.

After World War II, most G-21s were quickly phased out of military service, but the Goose renewed its career as an airliner. Uniquely adapted for travel in virtually any environment, the Goose saw widespread service with small airlines in the Caribbean, California, and Alaska. Among those flying the G-21 were Reeve Aleutian Airways, Alaska Coastal Airlines, Chalk's Flying Service, and Mackey Airlines. Antilles Air Boats was particularly noted for flying the Goose around the Caribbean from its base in St. Croix in the Virgin Islands. Avalon Air Transport (later Catalina Airlines) competed for a while with Catalina Seaplanes, connecting southern California with Catalina Island.

The Grumman G-21A in the National Air and Space Museum's collection was built in 1938 for the Venezuela Oil Development Branch of the Asiatic Petroleum Company. It was delivered on December 10 without luxury appointments, but it was outfitted with special cactus-proof tires for operation in remote areas. It was later sold and flown in Ecuador until 1951, when it was returned to Grumman and refurbished with soundproofing, a camera door, and new paint. For the next 30 years, the G-21 was flown as an airliner. It became part of the Museum collection in 1983.

The Grumman Goose still flies today, both in its original form and with turboprop engines added for increased performance. For over 50 years, the rugged and versatile G-21 has performed its daily tasks, providing much-needed service carrying passengers and freight throughout the world.

—F. Robert van der Linden

Adapted from Aircraft of the National Air and Space Museum, *edited by F. Robert van der Linden, Smithsonian Institution Press, 1998.*

MUSEUM CALENDAR

April 20 Book signing by Brigadier General Paul W. Tibbets Jr. (USAF, ret.), who piloted the B-29 *Enola Gay*, which dropped an atomic bomb on Japan during World War II. Tibbets will sign copies of *The Return of the* Enola Gay, which can be purchased at the National Air and Space Museum. Noon to 4 p.m. Call (202) 357-3762 for more information.

April 21 Brigadier General Paul W. Tibbets Jr. (USAF, ret.) will give a lecture on U.S. Army Air Force bombing operations in the Pacific Theater during World War II. Tickets required; call (202) 357-3762. Langley IMAX Theater, 8 p.m.

April 21 Family Day. Looking at Earth gallery, 10 a.m. to 3 p.m.

May 3 The National Air and Space Museum celebrates International Space Day from 10 a.m. to 3:30 p.m. For more information, visit www.spaceday.com.

Monthly Star Lectures
These astronomy lectures are held on the last Saturday of each month. Call (202) 357-1530 for more information. Einstein Planetarium, 6 p.m.

Curator's Choice
Once a week a Museum curator will give a 15-minute talk about an artifact. Meet at the Museum Seal in the Milestones of Flight gallery at noon. April 4, "The Global Positioning System"; April 11, "Yuri Gagarin: The Legends of His Life and Death"; April 18, "Mars Global Surveyor"; April 25, "New Views of Earth Using Microwave Sensors."

Daily Activities
Highlights of Flight. Explore the Museum—from the Wright *Flyer* to the Space Age—through docent-led tours. Information Desk, 10:15 a.m. and 1 p.m.

Forces of Flight and Paper Airplane Contest. Science comes alive during these staff-led demonstrations in the How Things Fly gallery. Daily schedule posted at gallery entrance.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.edu or call Smithsonian Information at (202) 357-2700; TTY (202) 357-1729.

Stealing the Show

For a young fighter pilot, Europe in the 1950s was an exciting place to be. The Canadian NATO air contingent in Europe was located at two bases in France, Marville and Grostenquin, and two in Germany, Zweibrücken and Baden Sölingen. At each was a fighter wing of three F-86 Sabre squadrons.

Not only was the exposure to different cultures fascinating, but the flying was the best to be had anywhere. The rules of engagement were practically nonexistent. We attacked, in mock combat, Royal Air Force and Belgian Hawker Hunters, French Mystères and Vautours, Dutch Vampires, German Thunderstreaks and Sabres, U.S. F-86Hs, RB-66s, F-86Ds, and each other. Anything was fair game.

It was good fun and at the same time honed our skills for a confrontation with Ivan, should he and his minions ever come west. The tactic, unchanged since World War I, was to get as high as we could, with the sun at our back, then swoop down on some hapless target before he knew we were there. As it was generally considered in poor taste to actually shoot down an ally, we had to content ourselves with recording the "kill" on gun camera film. This footage was later screened in debriefings, accompanied by considerable ribald commentary.

These encounters were often hairy and sometimes fatal. If the target was alert to the attack, he would often break in either direction, climb, or both. Then began the "high scissors," with each aircraft turning into the other and reversing the turn as they passed dangerously close, the object being to get on the other's tail for the shootdown. As energy was lost during the high-G turns, the airspeeds got lower and lower. To stall the aircraft was to invite disaster. The only way to regain energy necessary for the turns was to descend, eventually ending up in a "low scissors," sometimes right at the treetops. It was a game of aerial chicken that on occasion resulted in collision. Eventually the procedures were drastically modified—perhaps to the possible eventual benefit of the MiG pilots whose contrails we saw practically every day, to the east. But we were young, relatively well paid, flying the hottest fighter in Europe, and, in our minds, invincible.

The Brits were coming out with what would be called the English Electric Lightning, the French with the Super Mystère. And the Mirage was already in experimental flight test. What did the Americans have up their sleeves to replace their F-86s in Europe?

That was the scenario as late one sunny morning, Flying Officer Dave "Crocodile" Alexander of the Royal Canadian Air Force's 413th Fighter Squadron ambled across the ramp toward a Canadair F-86 Mk.VI Sabre, signed out for a test flight following some maintenance work. (His reptilian sobriquet had come from an incident in which he had allegedly bitten the commanding officer's wife on the ankle during a mess party.)

Alexander began his preflight inspection, being particularly attentive to the job at hand. One didn't take anything for granted with an aircraft that had just come out of major maintenance. Who knows what mechanic had had an overdose of suds at the local Gasthaus the night before and left a wrench in the landing gear retract mechanism, or what crew chief had had a fight with his wife and, distracted, signed off on all items without personally checking? A Martin Baker ejection seat notwithstanding, it was Alexander's life at risk.

Satisfied that everything checked out, he strapped himself into the cockpit, then twirled his finger at the ground crewman to indicate engine start. Five minutes later he was airborne.

All Canadian aircraft in the late 1950s were camouflaged in dark brown and green, so they were difficult to see from above against the European countryside. We never understood whether it was arrogance or just stupidity that dictated all U.S. Air Force aircraft be as silver as the day they were born. A flash of sunlight off aluminum made them easy to spot long before the actual aircraft could be seen.

The first part of the test flight was to be conducted at low altitude, and Alexander, once a safe distance from base, began going through the test checklist, recording readings as he continually scanned outside the cockpit. Any fighter pilot who kept his gaze inside the office longer than 15 seconds at a time sooner or later ended up road kill. It was during one of these eyeball sweeps that Alexander noticed a flash in the sky, high to the east.

Well, the test flight could wait. Might be a MiG-17, threatening the security of Western Europe, all by itself. Maybe only a French Mystère. Didn't matter. Checking out a strange bogey was his sworn duty.

Staying low, Alexander headed east. There! Whatever it was flashed again. Closer, he could see three aircraft, circling to the left in a "V" formation at about 6,000 feet. Arriving underneath the trio apparently undetected, he began a slow, climbing spiral in their blind spot and was able to slide directly behind and below the lead aircraft. What were these ugly silver monsters with blackened afterburner nozzles, swept-back wings, and drooped snouts? At least their fuselages had the U.S. insignia, which was comforting.

Below and 10 miles away from the circling aircraft was Ramstein Air Force Base. Bleachers were set up on the ramp facing the runway, and in those bleachers

WAYNE SHIPP

sat the cream of the allied forces in Europe, with various government and civilian dignitaries from the surrounding German towns.

The occasion was the arrival in Europe of the F-100 Super Sabre day fighter, supersonic in level flight and heralded as the guarantor of air superiority throughout Western Europe. At least that's what the public affairs officer was probably telling the assemblage in the bleachers via the public address system, directing them to look to the east as the control tower called the formation leader in to initiate a pass in front of the crowd.

Alexander was getting some nice film on the gun camera when he noticed the formation steepening the turn and starting a descent. Not being on the same radio frequency as the F-100s, he had no idea what was going on, but decided to tag along for grins. This required adding some throttle, as the much heavier Super Sabres were gaining more speed than the F-86 in the descent.

Sneaking only a quick peek away from the formation, Alexander saw they were lining up on the main runway at Ramstein and descending faster. At this point, black smoke began pouring out of the tail pipes of all three aircraft as they began to pull away. *Not without me, guys*, he thought as he jammed the throttle forward.

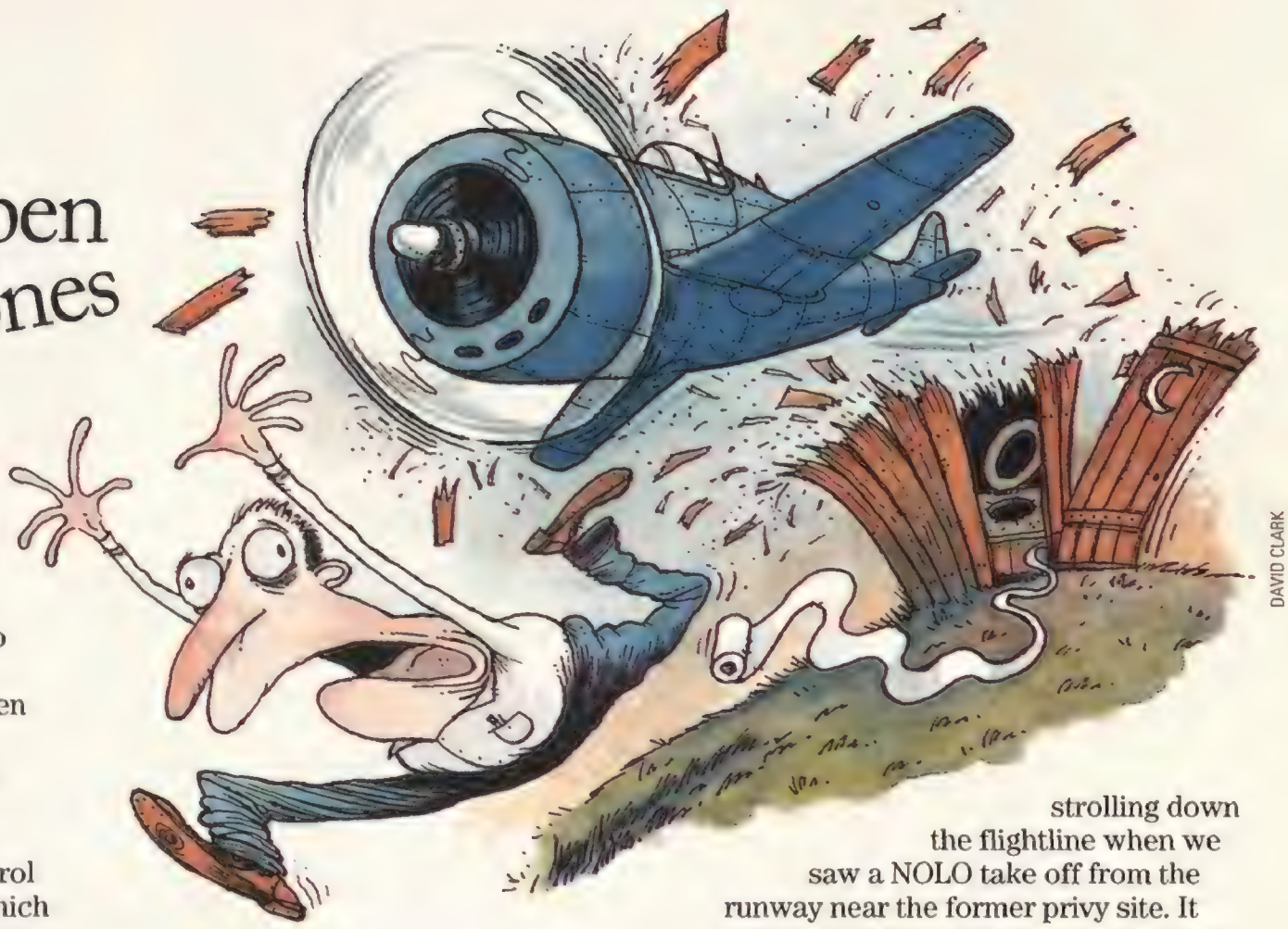
But Alexander was losing it. With the throttle to the stops, the aircraft was shaking so badly it felt like a bucking bronco. He was just starting to slide backward from the trio ahead as they flashed by in front of the crowd: three silver top-of-the-line fighters and one grimy, camouflaged something or other with a red ensign on its tail.

As the F-100s banked and climbed to the left, Alexander broke right and headed for home, exultant. This was some serious coup! But he had also glimpsed the turnout on the ground and realized he'd been where he shouldn't have. Better do an extra-long test flight so he could collect his thoughts and come up with a good alibi.

Sure enough, as the tires of his Sabre touched the runway, a delegation was there to meet him. After the obligatory chewing out, with the commanding officer trying not to break into a giggle, Alexander modestly proceeded to the officers mess, gun camera film in hand. It is difficult to be humble when you've got three Super Sabre "kills" on film, your mates are carrying you through the bar on their shoulders, and drinks are on the house. He never even tried.

—Doug Hinton

When Bad Things Happen to Good Drones



DAVID CLARK

As a technical advisor for the Allison Engine Company, I was assigned in 1955 to the Naval Air Missile Test Center at Point Mugu, California, where the Navy tested air-to-air-missiles. Because the missiles had to have something to shoot at, Point Mugu had a fleet of F6Fs and other airplanes that had been converted into drone targets.

The F6F drones flew in one of two modes. In NOLO mode, No Live Operator was aboard. Two piloted T-28s flew alongside: the first to control the drone in flight and the second, which had been specially modified for the job, prepared to shoot it down if it went out of control.

In Fox Bounce mode, the drone's flight was also controlled by an accompanying T-28. However, the drone had an actual pilot on board. He was there only to take over if the drone went out of control. When things were going correctly, he was forbidden to touch the drone's controls. I had a Navy engine specialist trainee recently arrived from Germany working with me who marveled at the safety pilot's self-control. "Chust tink," Bruno often said, "he must zit und der cockpit mit der hands gerfolden."

At the time, my primary duty was to oversee the McDonnell F3H-2 Demon's afterburning turbojet engine as that fighter-interceptor was introduced into service. We had a pad in the middle of the airfield where F3Hs were run up. These troubleshooting sessions went on for so long that a privy had been erected nearby. One day we had been on the run-up pad with a Demon for several hours. We were about ready to drive back when Bruno indicated that he wished to visit the facilities. I pulled off the taxiway and waited for him.

The wooden shed where Bruno headed was less than 200 feet from the active runway. While he was occupied, I noticed an F6F Hellcat NOLO lining up to land on the runway closest to us. I watched the drone swerve as the operator tried to keep it on track. He started to flare the craft for landing, but the airplane wasn't going to make it. It mushed to the left and, still about 10 feet off the ground, headed directly toward Bruno's temporary residence.

Bruno emerged, facing me and smiling contentedly. Behind him, the F6F was bearing down on him and the shed, but in the noisy Mugu environment he could not hear the drone's engine. I gave him frantic arm and hand signals, and when he finally looked behind him, he started running like a supercharged gazelle. He just managed to clear the F6F's path before the drone went through the privy, its big propeller munching up the boards.

For weeks afterward, whenever he was outdoors, Bruno watched the sky. He looked like a chicken watching for chicken hawks.

One afternoon Bruno and I were strolling down the flightline when we saw a NOLO take off from the runway near the former privy site. It climbed to about 200 feet in a semi-stall, the engine putting out little more than 75 percent power. The left wing dipped and the aircraft wallowed in a slow turn.

We were standing beside a series of hangar walls—nothing but concrete up to 60 feet and nowhere to run, with the airplane headed directly at us.

Bruno began running. This led him right into a concrete wall. He fell to the ground, got up, and proceeded to do exactly the same thing. And then exactly the same thing again: He ran a little way from the wall, looked up at the drone, turned, and this time went about three feet up the wall before falling. In his next attempt he got about six feet up.

The NOLO fluttered directly overhead, so close I could hear the wind whistling through its undercarriage. Then it crashed into a parking lot behind the hangars, about 200 feet from us.

Bruno's climbs left black heel marks on the concrete wall. We later implanted brass markers shaped like little heels into the concrete to commemorate the remarkable feat. Bruno was often asked to repeat his achievement, but he always demurely declined.

—O.H. Billmann

"This place is a pilot's heaven..."

PHOTO: CAROLYN RUSSO

"The National Air and Space Museum has been a major part of our lives for almost 30 years – and today the new Steven F. Udvar-Hazy Center is, as well. Our contribution will help to ensure the success and growth of both."

—DEPUTY DIRECTOR OF THE NATIONAL AIR AND SPACE MUSEUM LT. COLONEL DONALD S. LOPEZ, USAF (RET.), AND HIS WIFE GLINDEL. They're standing in front of the North American P-51D Mustang now displayed in the World War II Aviation Gallery. It's one of the many aircraft Don Lopez piloted in his long and illustrious career.

He became a WWII fighter ace harassing Japanese forces in a shark-mouthed P-40 in China. He's been a test pilot, flown jets in the Korean War, taught at the U.S. Air Force Academy, worked on the Apollo-Saturn and Skylab programs, and written books on his experiences. He made aerospace history, and today he works to preserve it for the future. Don and Glyn Lopez care deeply for the National Air and Space Museum and its work to preserve the history of flight. They're honored to include the Museum in their will, and are proud members of the Smithsonian Legacy Society.

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THE CROWDS SWARM ONTO THE BASE IN THE HEADY JULY SUN TO FEEL THE GROUND SHAKE AND TO CRINGE AT THE THUNDER OF AFTERBURNERS. RICK SVETKOFF AND TOM DELASHAW ARE PLEASED TO OBLIGE THEM—ALL 250,000 OF THEM, SITTING ON BLANKETS AND LAWN CHAIRS AND COOLERS AT THE SELFRIDGE AIR NATIONAL GUARD BASE IN MOUNT CLEMENS, MICHIGAN.

Having wowed the crowd, a Starfighter returns to Earth.

"It's rocket time!" says Svetkoff, a lanky 46-year-old in a blue flightsuit. He straps silver spurs to his black boots and climbs into the cockpit and attaches the spurs to the ejection seat of the Lockheed F-104 Starfighter, an airplane that, nearly 50 years after its first flight, still causes heads to turn and jaws to drop. Assistant crew chief Andy Bales helps fasten the harness around his shoulders, torso, and legs.

"You all set?" Bales says.

"All set," says Svetkoff, slipping on his helmet.

"Be careful up there," Bales says.

Svetkoff's Starfighters, Inc. of Clearwater, Florida, bills itself as "the world's fastest flight demonstration team." With its two F-104s, the team represents a new high on the airshow circuit: civilian-owned supersonic jets flying in formation (though speed for all aircraft is limited to Mach .98 over populated areas—no sonic booms allowed). With the planned addition of a third Starfighter this year, Starfighters, Inc. is chasing the elite of the airshow circuit, the Air Force Thunderbirds and the Navy Blue Angels. Svetkoff and Delashaw routinely fly faster in both level flight and climb than either team.

"The Blue Angels and Thunderbirds are the Rolling Stones of the airshow business," says John Cudahy, president of the International Council of Air Shows. "When they come, big crowds come, and when big crowds come, they buy a lot of T-shirts and hot dogs and see sponsors' products."

Fifteen to 18 million people flock to some 425 airshows in the United States and Canada every season. The big ones—Selfridge in Michigan, Miramar in San Diego, the Oshkosh, Wisconsin fly-in, Naval Air Station Jacksonville in Florida, to name a few—draw hundreds of thousands, sometimes over a million, spectators in a weekend. No one knows exactly how big the business is, but ICAS guesses $100 million is spent in producing airshows, with at least an equal amount spent by those attending them. And the Angels were scheduled at just 35 shows last year. Svetkoff foresees a civilian team rivaling the military headliners. "We're not a novelty act," he asserts. "We're a formation jet demonstration team. And we generate more thunder than anyone out there."

A primitive, pulsating howl cuts the air. *Hooowha. Hooowha.* The two sky-blue Starfighters taxi down the runway in formation, 1,500 feet from the crowd, emitting a scream that brings to mind dragons and dinosaurs. It's a sound unique to -104s with GE-J79-3, -7, or –11 engines, says Delashaw, due to the configuration of the primary and secondary exhaust nozzles on the tailpipe. At certain engine speeds, exhaust gases rushing past the gap between the primary nozzle and the secondary, which is larger in diameter and aft of the primary, produce the howl the same way that blowing over the opening of a beer bottle produces a distinctive note. Earlier models of the F-4 Phantom were howl-capable, Delashaw says, but to a much lesser extent. "We accentuate it by moving the throttle in a particular range," he says. "It's a real attention getter, one aspect among others setting us apart from other jet acts."

THE FASTEST SHOW ON EARTH

BY CARL HOFFMAN PHOTOGRAPHS BY TIM WRIGHT

HOW TWO LOCKHEED F-104 STARFIGHTERS

BECAME AIRSHOW STARS.

"From the time I was a kid, the 104 had been my favorite airplane. It's just beautiful and it accelerates like a rocket ship." RICK SVETKOFF

Mesmerized, the crowd stares at the blue missiles screaming down the runway and lifting into the clear air. "It's rocket time!" Delashaw calls out, and Svetkoff echoes him. Svetkoff has done this dozens of times but his heart is beating fast, adrenaline flooding his body. Delashaw, at 64, has done it too many times to count, from Hahn, Germany, to Key West to Da Nang. But it's making him feel young again, keeping him alive, he says.

They lift the nosewheels off and are flying at 205 mph, and by the time they're hitting the end of the runway a second later they're already passing 350. "Break now," Svetkoff, in the lead, calls, and banks hard to the right. It's the signal for Delashaw to pull the stick back and pitch straight up, like an arrow coming out of a bow; then he rolls inverted, quickly levels off at 7,000 feet, and accelerates to catch Svetkoff. Around they come in close formation in a 2.5-mile oval. "Starting the turn," Svetkoff says, pushing the speed to 400. "Rolling out for the first pass. Call the howl," Svetkoff says, and adjusts his power setting until Delashaw can hear that unique scream emanating from Svetkoff's airplane. Delashaw matches the power setting, and together, at 200 feet, they dart down the flightline like blue lightning bolts.

This is exactly what Svetkoff imagined it would be like, hurtling along in his Starfighter, the audience oohing and ahhing, when he first got the idea in 1988: He would buy a fighter. Not just any fighter, but one of the fastest ones in the world, the one rolling and

Afterburners ablaze, the F-104s don't so much take off as launch.

plummeting to "High Flight" when a TV station signed off late at night, the one that still holds a low-altitude speed record. "From the time I was a kid, the 104 had been my favorite airplane," Svetkoff says. "It's just beautiful and it accelerates like a rocket ship." The idea was crazy; Svetkoff had never flown a 104 in his life. And civilians who own and fly rare warbirds and high-performance jets are usually by necessity rich, and Svetkoff isn't.

"Yup," says Delashaw, a white-haired retired Air Force fighter pilot, "I heard through the grapevine about this crazy airline pilot who was trying to buy a 104. I couldn't understand how he was going to finance it."

Svetkoff, who flew Navy jets in the 1970s and has been a Continental Airlines captain for 15 years, started small: At first he'd just wanted to own and fly something fast—an F-86 maybe. But then he heard that a couple of government contractors who had imported five 104s from the Jordanian and Norwegian air forces, hoping to use them as test beds for research-and-development contracts, might put the aircraft up for sale. The idea was captivating. Owning one of these exotic craft would be like marrying Raquel Welch or Marilyn Monroe. And then it hit him: airshows. He'd been to his first, here at Selfridge, as a kid back in the early 1960s. *If I could get something so sexy, so top-shelf, that people would drop their hot dogs and stare when I fly by,* he mused, *then sponsors would pay to have their name on the side of my airplane.*

In 1995, after taking out a third mortgage on his home, Svetkoff married the sexiest icon of his youth. (The deals were helped along by the financial woes of the F-104 owners before him.) He became the owner of a Canadian two-seat CF-104D and a single-seat CF-104, both flown by the Norwegian air force, and a low-time but unflyable F-104B from the Jordanian air force.

Perhaps the most important acquisition was Delashaw, who had tracked down Svetkoff when he heard that Svetkoff was in the market for a 104. First checked out in the 104 in 1961, Tom "Sharkbait" Delashaw is a veteran of the 479th Tactical Fighter Wing, the only U.S. wing to fly the 104 in combat. He flew two tours of duty in Vietnam in the late 1960s, including 100 sorties over North Vietnam, mostly combat air patrol in F-104s and night strikes in F-4s. He also flew the 104 as a maintenance test pilot, graduated from the Air Force Fighter Weapons School in Nevada, wrote some official weapons manuals for it, and still holds his unit's speed and altitude records: 1,500 mph and 92,000 feet. With 2,700 hours logged in 104s, Delashaw was still nuts about the airplane. As a hobby, he keeps tabs on every 104 flying. Although retired from the Air Force since 1987, he is a self-described "time hog," designated by the Federal Aviation Administration to instruct in and give check rides for the few civilian owners of 104s, F-4s, F-100s, and Hawker Hunters. He is also a formation instructor in the warbird community and teacher of air combat for Texas Air Aces in Houston. And his best friend is Ben McAvoy, a Lockheed Starfighter maintenance rep since 1956 and a former crew member for Darryl Greenamyer's record-setting 104, which had been built from spare parts (see

The leading edge of the F-104 wing, essentially a big double-edge razor blade, has been known to slice those who duck under it carelessly. Below, the F-104's proper name makes a boffo airshow team title.

A fashion must for F-104 drivers, spurs secure the pilot's legs to the ejection seat. The ultimate in pointy jets (below), the Starfighter is not for the faint of heart, be it pilot or audience. Delashaw (left), with plenty of F-104 time, has schooled Svetkoff in the aircraft's nuances.

"Back in the Race," Aug./Sept. 2000). Delashaw could teach Svetkoff how to fly 104s, and his friendship with McAvoy put the foremost authority on the aircraft's technical ins and outs a mere phone call away. "Tom had a total knowledge and understanding of the plane," Svetkoff says.

That's important with any airplane, but it is especially true of the Starfighter, an airplane revered for its performance but long maligned by people who never flew it. Its design originated with Lockheed's Kelly Johnson quizzing veteran pilots in Korea in 1952, whose F-80s, F-84s, and F-86s had a hard time going up against North Korea's MiG-15s. We want more speed, a better climb rate, and a higher ceiling, they told him. Something simple and light. Johnson returned to California and, unsolicited by the Air Force, designed an airplane. If you build it, they will come, he believed, and sure enough, a year later the Air Force issued an order for a lightweight air superiority fighter. The airplane that Lockheed test pilot Tony LeVier first flew on March 4, 1954, the XF-104, was an engineering tour de force. It was all fuselage, a long, clean dart with stubby, straight wings so thin they were essentially big double-edge razor blades. Two small engine intakes on either side of the cockpit were the only interruptions to air flow. In 1956 it became the first fighter to exceed Mach 2 in level flight. The Air Force ordered 147 single-seat F-104As. Within three years Starfighters shattered every record in the book: speed (1,404 mph), altitude (103,395 feet), and seven time-to-climb records. Later, rocket-powered NF-104s would unofficially reach 130,000 feet, Chuck Yeager would fail to recover from a flat spin in an NF-104 at 104,000 feet and eject at 11,000 feet, and air racer Darryl Greenamyer would set a low-altitude speed record of 988 mph, which still stands, in a homebuilt 104.

For all its remarkable performance, however, by the time the 104A was delivered, the Air Force was looking at multi-mission-capable aircraft like the F-105. The 104A could not carry bombs, a deficiency that reduced its utility as a tactical fighter. Bugs in the original J79 powerplant rendered it unreliable. And its ejection seat, designed to eject downward because pilots may not have cleared the T-tail at high speeds, was a killer: 21 pilots died in downward ejections. Of the 722 Starfighters eventually ordered by the Air Force, only 296 were delivered, and most of those soon found their way to Air National Guard squadrons.

PAUL DIMARE

Kelly Johnson's Hot Rod

According to the late Lockheed designer Kelly Johnson, when test pilot Tony LeVier first saw the F-104, he asked, "Where are the wings?" Mounted mid-level far back on the fuselage, they total a mere 196 square feet.

Johnson and Bill Ralston designed the fighter-interceptor with an eye to compactness, low weight, ease of maintenance, and above all speed. A semi-cone ran along the long, needle-nose fuselage, just ahead of the air intakes, to manage airflow at supersonic speed. A T-tail sat high on the dorsal fin, and the negative dihedral wing bore trailing edge and leading edge flaps. A ventral fin, lacking on the prototypes, was added to improve stability.

Without a Mach-2-capable wind tunnel, Johnson came up with an ingenious method of testing the thickness and flutter tendencies of the short, thin wings, the all-flying tail, and the air intake ducts. He enlisted the assistance of a lieutenant general in the Air Force's Air Research and Development Command in Baltimore to procure five-inch rockets to which would be attached models and instrumentation. The general sent a message to troops in Korea: "Stop shooting rockets for one morning and send them all to Kelly." Two weeks later, the Skunk Works had nearly 500 rockets on hand, which it began flight testing at speeds up to 1,500 mph.

When Germany selected the F-104G in 1958, the lightweight fighter-interceptor was transformed into an all-weather, multi-role attack fighter at a considerable weight penalty. "Takeoff speed had to go way up," Johnson wrote. "The airplane had become a hot rod of the first order."

Thoroughbred though it was, the 104 might have disappeared in ignominy if Germany and NATO hadn't selected the G model in 1958 as their main platform to deliver tactical nuclear weapons against the Warsaw Pact. Compared with the A and C models (the B and D models were two-seat trainers), the F-104G could carry 8,000 pounds of external stores and the avionics for all-weather capability. But pilots died in it. German pilots crashed two in 1961, seven in 1962, 12 in 1964, and 28 in 1965. By the time Germany retired its 104s, 270 aircraft—nearly 30 percent of its total force—had been lost to accidents, and 110 pilots had died.

Still, over the next three decades, some 2,580 Starfighters had been produced, most under license from Lockheed, in Germany, Italy, Belgium, the Netherlands, Canada, and Japan. Although the Luftwaffe operated 35 percent of all 104s built, Starfighters were eventually flown by Italy, Belgium, Norway, Denmark, Canada, Greece, Turkey, Spain, Taiwan, Jordan, and Pakistan. Even today, Italy flies 64 highly upgraded F-104S models.

Ask Delashaw about the 104's checkered reputation and he scoffs. Is a race-prepped Ferrari an easy car to drive? If you handed the keys to your teenage son, would he live to tell the tale? German pilots went from the "all-visual subsonic F-84 and F-86 to a Mach 2, low-level, all-weather fighter," he says. "That's a huge leap in performance." And most had little or no experience in any kind of airplane. "The Germans learned to fly in 150 hours at Wichita Falls, Texas. Then we'd give them 150 hours on the 104 at Luke Air Force Base, Arizona. Then they'd go back to Germany and get a European check and be tossed out on their own. You had pilots with 500 hours of time flying this high-performance airplane in bad weather at 200 to 400 feet; it was a very difficult and intense work environment."

Pilots like Delashaw who mastered the Starfighter loved it like no other. Spain, he points out, never lost a 104. And in 56,000 hours of flying time Norway suffered but six crashes.

With Delashaw on his team, Rick Svetkoff was off to join the flying cir-

"God, I was having fun! I was so fast I was at Mach .94, right on the edge. I had to come back on the power or I would have gone supersonic." TOM DELASHAW

cus. "Rick's theory," says Delashaw, "was that people at airshows don't care if you fly a biplane that can do weird stuff; what they really want is something loud, sexy, and fast," preferably with multiple aircraft in formation, basically the stuff of the military jet teams.

Every December ICAS holds its annual convention, where airshow acts sell themselves to airshow producers for the coming season; Svetkoff attended his first in 1995. "Everyone had these big booths," Svetkoff says, "and that first year we had no money and just three little photos of the planes, but we had more people hanging around our area than anyone. They were all saying 'Are you guys actually going to show 104s?' " Broke and unpracticed, Svetkoff's Starfighters, Inc. booked only two shows that season. But over the next year Delashaw checked Svetkoff out and taught him the finer points of flying the high-performance jet, and the two developed a simple routine based on Svetkoff's premise: lots of high-speed passes and pullups showcasing the airplane's howling sound, speed, and unparalleled rate of climb. The next December they came to the convention with a big booth, lots of photos, and a sound system pumping out that howl. They've barely paused since, performing at 12 to 15 shows a season, mostly big military shows like this one at Selfridge.

"People like thunder and noise," says Lieutenant Colonel Thomas Bankstahl, who, as director of the Selfridge Air Show, booked Starfighters, "and anything more than a solo act is a real bonus. These guys fit the bill." And it doesn't hurt that while the Blue Angels require services and support worthy of a superstar entourage, including 55 hotel rooms, police escorts, an army of cars and vans, and 'round-the-clock security, Starfighters needs only two cars, three hotel rooms, two auxilliary power units, and an oxygen cart.

"Here they come!" someone yells...and they're gone, Svetkoff and Delashaw completing the first photo pass at a measly 400 mph, that wailing sound pressing over the crowd like the end of the world. They bank right, loop around, and here they come again. "Flaps," calls Svetkoff in the lead, and both pilots retract the flaps. "Sector," Svetkoff says, and they push the thrust up and accelerate into "sector burner," the initial afterburner setting. The air is cool and dry and the 104s leap forward like there isn't any air at all; in an instant they're nosing Mach .92, over 700 mph, a few hundred feet above the ground. "Pull now," Svetkoff says, and Delashaw pitches vertical, pulling 7 Gs, shooting straight up at 1,000 feet

STARFIG

Start with a powerful jet engine, then add sawed-off wings and a pilot. Combine ingredients and hold on tight. ✪ Designed by Kelly Johnson and first flown in 1954, the Lockheed F-104 Starfighter was the first interceptor capable of sustained speeds above Mach 2, and it set a succession of time-to-climb, speed, altitude, and time-to-intercept records, including flights that reached 1,404 mph and 103,395 feet. But for sheer power, nothing could beat NASA's NF-104s, which featured auxiliary liquid fuel rocket engines, reaction control systems, and the capacity to boost lucky astronaut trainees to 130,000 feet—the edge of space.

✪ Despite the Starfighter's impressive talents, its utility in combat was limited. As the U.S. Air Force began to value fighters with longer range and greater multi-role ability, the F-104's career was cut short. Only one Starfighter-equipped unit was deployed to Vietnam, where the aircraft flew combat air patrol and close air support missions but didn't down any MiGs.

✪ But for other nations, the Starfighter shined: Most of the 2,500-plus aircraft produced were F-104Gs, which were exported or built overseas. The much-impoved, all-weather G model could carry 8,000 pounds of external stores and doggedly stayed on the front lines of some air forces well into the 1980s and 1990s. Today, Italy still flies the F-104S, the most highly developed version of the nearly-50-year-old "missile with a man in it."

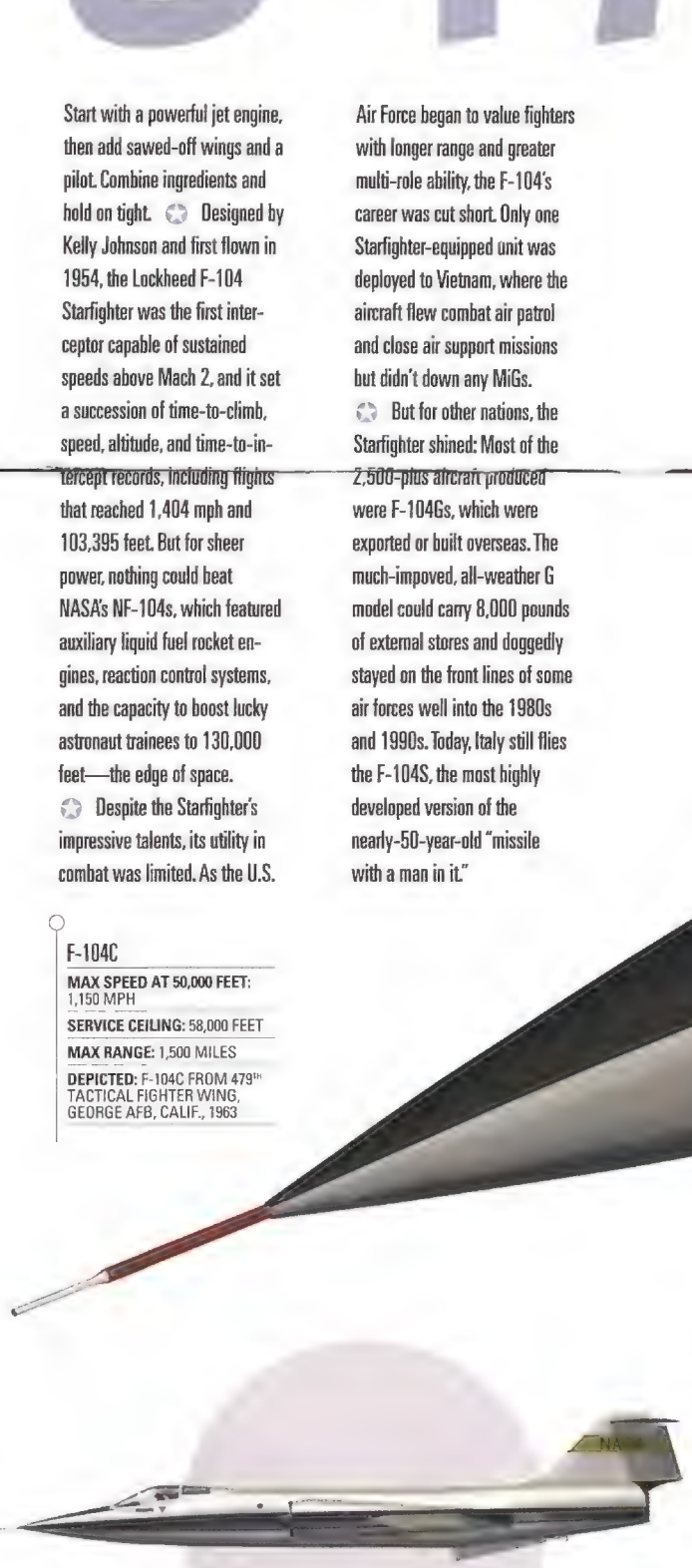
F-104C

MAX SPEED AT 50,000 FEET: 1,150 MPH

SERVICE CEILING: 58,000 FEET

MAX RANGE: 1,500 MILES

DEPICTED: F-104C FROM 479TH TACTICAL FIGHTER WING, GEORGE AFB, CALIF., 1963

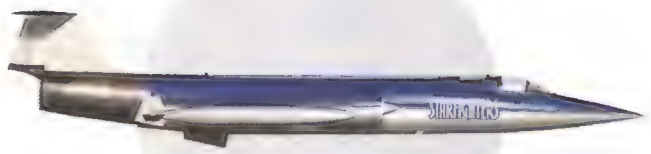


NASA used a total of 11 F-104s as chase planes until the last Starfighter was retired in 1994.

Germany was the largest operator of Starfighters, fielding more than 900 before they were withdrawn in the late 1980s.

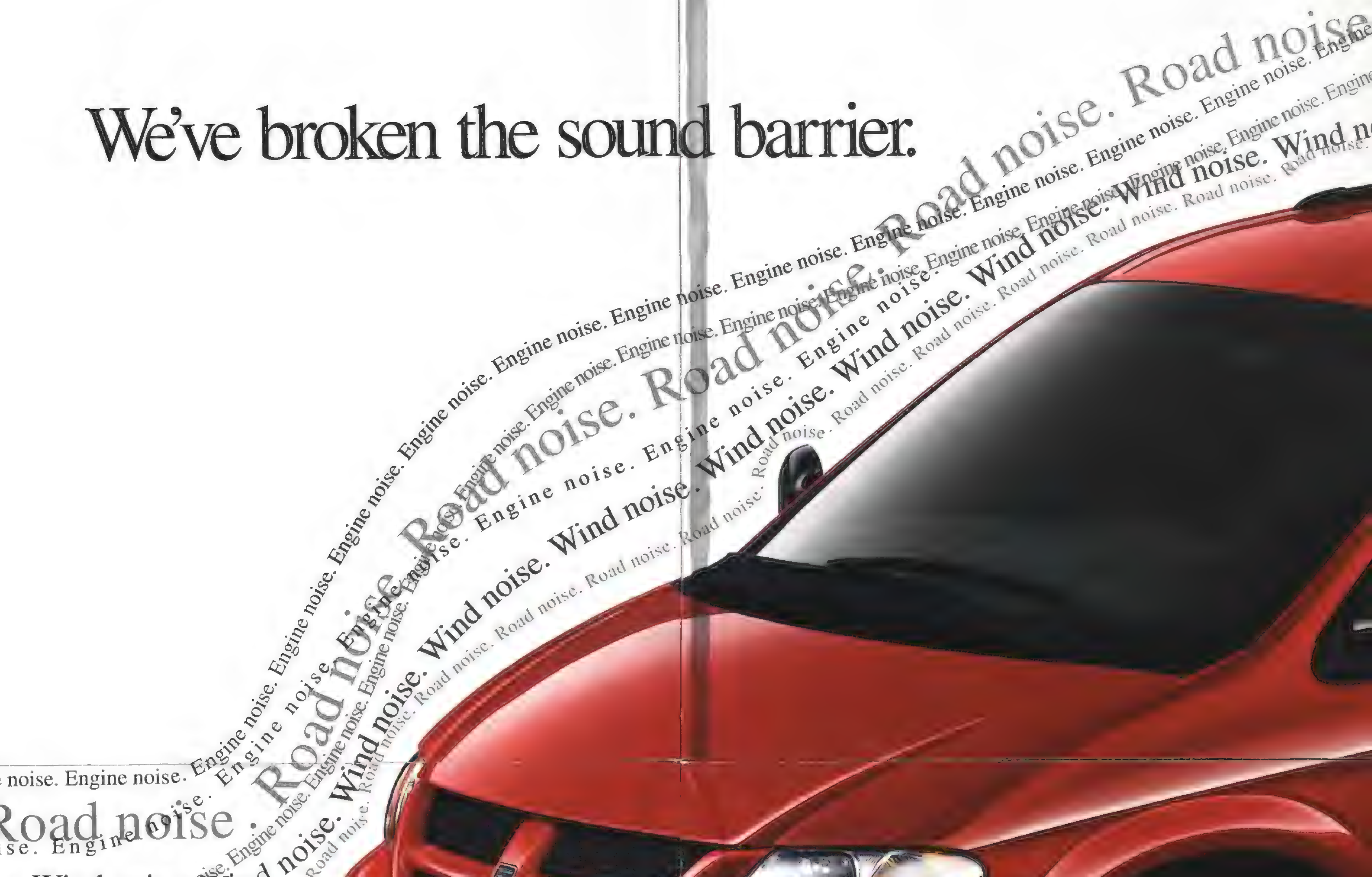
HTER

Italy has remained one of the Starfighter's most steadfast users; a colorful paint scheme for Tiger Meet—a gathering of squadrons with tigers in their heraldries—adds flair to the F-104's no-nonsense appearance.



The only airshow act in the world to fly the F-104, Starfighters, Inc. turns jet fuel into the distinctive Starfighter howl.

We've broken the sound barrier.



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Svetkoff uses hand signals to communicate with the crew during an engine runup. Three fingers means "engine accelerating through 30 percent."

per second. The F-104, as pilots like to say, is not "power limited."

After Delashaw blasts skyward, Svetkoff spirals into a series of 700-mph corkscrew rolls, rolls out, and banks right to loop around for another pass. Delashaw, at 15,000 feet, has disappeared into the blue.

Svetkoff is flying his dream, but all isn't quite perfect. The F-104 Starfighter was built for national militaries to fly, not airline pilots. Every second he's up there he's burning money faster than the airplane is sucking fuel. Tires can cost up to $500 apiece and last for just 12 to 15 takeoffs and landings. A thorough engine inspection costs $200,000. The aircraft are so expensive to fly and maintain that Delashaw and Svetkoff spend a few days before the season practicing and then pretty much fly only for shows. Bales receives but a stipend for his weekends on the airplanes and Delashaw is not paid. And to keep them flying takes a full-time crew chief, who doesn't come cheap.

Svetkoff's sitting on top of the world, but he needs a sponsor to stay there. An airline pilot's pockets aren't deep enough to fully fund an F-104 team.

The current schedule alone, Svetkoff figures, costs upwards of $400,000. Shows pay up to $15,000 an appearance (Selfridge paid $12,000), although they throw in a car, hotel rooms, food, and fuel. Luckily, spare parts remain plentiful (a 104 awaiting restoration in the hangar at Clearwater is often cannibalized for parts), and the Starfighter is an unusually reliable airplane. And Svetkoff occasionally gets a few days of work flying his 104 as a test platform for military contractors. Still, Svetkoff won't be able to continue, and won't be able to fly a third 104, unless he can find a way to underwrite his act. ICAS president John Cudahy thinks it will happen. "Sponsorship in the airshow industry is increasing significantly," he says, "because corporate America sees an opportunity to get its message in front of a lot of people without a lot of clutter. When a performer flies, he's alone in front of his audience for 15 minutes. And Starfighters bring a lot of the excitement and raw speed and power that audiences like to see from contemporary military aircraft."

After six passes, Svetkoff banks right and touches down, drag chute popping out as he rolls out of sight. Delashaw is close behind, touching down on the main gear, holding the nose high almost the length of the runway in a display of aerodynamic braking. Seventeen minutes and a thousand gallons of fuel after takeoff, Starfighters' show is over.

"It's amazing that something man-made can make that much noise and go that fast," says spectator John Bristor.

"It's awesome!" says six-year-old Joshua Blackburn.

"I love it when they go straight up!" says Harold Logan.

Andy Bales chocks the airplanes as Svetkoff and Delashaw climb out. "God, I was having fun!" says Delashaw, his face gleaming with sweat. "I was so fast I was at Mach .94, right on the edge. I had to come back on the power or I would have gone supersonic. The air was so cool and dry it was unbelievable—I was hardly bleeding off speed when I went over the top at 15,000 feet and over 600 miles per hour."

It is 2 p.m. and their day is over. Someone whips open some folding chairs. A few cold beers appear. A succession of

The few, the proud, the patch wearers: Ben McAvoy downsized and reproduced the F-104 patch for the Starfighters team.

admirers find their way to the gleaming Starfighters. Delashaw has seen grown men cry in front of the airplanes, and one fan recently e-mailed him from Japan, on his way to see them at a show in Westover, Massachusetts. General Thomas Cutler, commander of the Selfridge base, pulls up in a golf cart and bounds over to the airplanes. "Outstanding!" he says, beaming. "That's the ultimate hot rod, isn't it? The F-16 is clean, but these 104s are cleaner. It is so cool; it's been the highlight of the show for me!"

And so it goes. For airshow performers, acts are 15 minutes of flying and 15 hours of socializing. The same performers see one another at every venue; at each there are parties and crowds of admirers. Late that night in the hotel bar Svetkoff and Delashaw are in the thick of it. Every room is booked with fliers and the bar is open, the beer gushing free to performers still dressed in their show flightsuits. There's Fowler "Big Dog" Cary and his sidekick J.R., who fly a T-33, clutching cigars and sporting mouthfuls of fake crooked teeth, pitchers of beer in hand and rows of Blue Kamikaze cocktails lined up on the bar. There's Miss Budweiser in her skin-tight black dress and high heels, keeping glasses full and egos brimming with a hug for even the sweatiest and most unsteady. There's a fistfight between an F-16 pilot and an Army Golden Knights parachute team member over some personal slight, then more drinks for everyone. "I'm not making any money," says Svetkoff grinning, his eyes sweeping over the late-night spectacle, "but how can you beat it? I'm in the carny!"

AIRSHOWS!

COMING SOON TO A FIELD NEAR YOU!

Alabama
Birmingham — Sept. 29 & 30
Wings & Wheels 2001
Maxwell AFB — Apr. 22
Wings Over Montgomery (Thunderbirds)

Alaska
Elmendorf AFB — June 30-July 1
Arctic Thunder 2001

Arizona
Deer Valley — Oct. 6 & 7
Phoenix-Deer Valley Air Show
Glendale — Mar. 31 & Apr. 1
Wings Over Arizona (Thunderbirds)
Kingman — Oct. 6 & 7
Kingman Air and Auto Show
Mesa — Oct. 11-14
Copperstate Regional EAA Fly-In
Page — Oct. 5 & 6
Page-Lake Powell Air Affair (Snowbirds)
Phoenix — Nov. 17 & 18
Luke AFB Open House
Scottsdale — Oct. 19-21
Scottsdale Airfair
Sierra Vista — Oct. 27 & 28
Desert Thunder Air Fest
Valle-Williams — June 23 & 24
High Country Warbirds Air Show

Arkansas
Fort Smith — May 13
Fort Smith Air Show (Thunderbirds)
Walnut Ridge — Oct. 13 & 14
Wings of Honor Airshow & Reunion

California
Beale AFB — Apr. 8
Beale AFB Open House (Thunderbirds)
Chino — Oct. 6 & 7
Planes of Fame Air Show
Edwards AFB — Oct. 20 & 21
Edwards AFB Open House
Half Moon Bay — Apr. 29
Pacific Coast Dream Machines Show
Long Beach — Oct. 27 & 28
Wings Over Long Beach
Moffett Field — Aug. 11 & 12
NASA e-Air Expo
NAS Lemoore — July 28 & 29
NAS Lemoore Central Valley Air Show (Blue Angels)
Paso Robles — Sept. 9
Paso Robles Air Show
Point Mugu — Apr. 6-8
Point Mugu Airshow (Thunderbirds)
Riverside — Mar. 24
Riverside Airport Airshow 2001
Salinas — Sept. 14-16
California International Airshow (Thunderbirds)
San Diego — Oct. 12-14
MCAS Miramar Air Show (Blue Angels)
San Francisco — May 5
Crissy Field Airshow
San Francisco — Oct. 5-7
San Francisco Fleet Week (Blue Angels)
Santa Rosa — Sept. 18 & 19
Wings Over Wine Country
Torrance — July 14 & 15
Torrance Air Fair
Vacaville — June 30
Solano Air Fair
Van Nuys — June 23 & 24
Van Nuys Aviation Expo
Visalia — Sept. 29
Vintage Years Air Show
Watsonville — May 25-27
Watsonville Fly-In and Airshow 2001

Colorado
Aspen — Oct. 3
Aspen Airshow (Snowbirds)

Florida
Daytona Beach — Nov. 10 & 11
Daytona Beach Air Show (Thunderbirds)
Fort Lauderdale — May 5 & 6
Fort Lauderdale Air & Sea Show (Thunderbirds, Snowbirds)
Jacksonville Beach — Nov. 3 & 4
NAS Jacksonville Air Show (Blue Angels)
Lakeland — Apr. 8-14
Sun 'n Fun EAA Fly-In
MacDill AFB — Apr. 7 & 8
MacDill Airfest (Blue Angels, Starfighters)
Mayport Naval Station — Nov. 3 & 4
Air Show
NAS Pensacola — Nov. 9 & 10
Blue Angels Homecoming (Blue Angels)
Pensacola Beach — July 13 & 14
Pensacola Beach Airshow (Blue Angels)
Pompano — Jan. 13 & 14
Air Force Association Air Fair 2001
Stuart — Nov. 10 & 11
Stuart Air Show

Georgia
Dobbins ARB — May 19 & 20
Dobbins ARB Open House
Moody AFB — Nov. 4
Air Show (Thunderbirds, Starfighters)
Peachtree City — Sept. 8 & 9
Wings Over Dixie
Robins AFB — Apr. 28 & 29
Robins AFB Open House (Snowbirds)
Vidalia — Apr. 28-30
Vidalia Onion Festival Air Show

Illinois
Bloomington — July 20-22
Prairie Air Show
Chicago — Aug. 18 & 19
Chicago Air & Water Show (Thunderbirds)
Rantoul — Aug. 4 & 5
Chanute Transportation Expo
Scott AFB — June 30-July 1
Scott AFB Air Show (Thunderbirds)
Springfield — May 11-13
Springfield Air Rendezvous (Blue Angels)

Indiana
Anderson — June 23 & 24
Anderson Airshow
Elkhart — June 1-3
Elkhart Airshow
Evansville — June 28-July 4
Evansville Freedom Festival (Blue Angels)
Fort Wayne — Aug. 4 & 5
Air Expo 2001
Indianapolis — Sept. 7-9
Indianapolis Air Show (Starfighters)
Muncie — Aug. 9-11
Summer Heat Balloon Championship
South Bend — Aug. 24-26
SkyFest Michiana, Inc.

Iowa
Davenport — June 23 & 24
Quad City Air Show (Blue Angels)
Sioux City — Sept. 8 & 9
Siouxland Air Show (Thunderbirds)

Kansas
McConnell AFB — June 23 & 24
McConnell AFB Air Show

Kentucky
Louisville — Apr. 21
Thunder Over Louisville

Louisiana
Barksdale AFB — Apr. 21
Barksdale AFB Open House (Thunderbirds)
Lafayette — Oct. 27 & 28
Sertoma Cajun Air Festival (Blue Angels, Starfighters)
New Orleans — Oct. 19-21
N'Awlins Air Show

Maine
NAS Brunswick — Sept. 22 & 23
Great State of Maine Air Show (Blue Angels)

Maryland
Andrews AFB — May 19 & 20
Joint Services Open House (Thunderbirds)
Annapolis — May 25
U.S. Naval Academy (Blue Angels)
Frederick — Aug. 18 & 19
Wings Over Frederick
NAS Patuxent River — May 26 & 27
Air Expo 2001

Massachusetts
Fitchburg — Sept. 13-16
Autumn Air-Fest
Otis ANGB — Aug. 4 & 5
Cape Cod Air Show (Thunderbirds)
Westfield — Aug. 18 & 19
Westfield International Airshow

Michigan
Battle Creek — July 4-8
Team U.S. Nationals and Battle Creek Air Show (Thunderbirds, Snowbirds)
Duluth — Aug. 25 & 26
Duluth Air & Aviation Expo 2001 (Blue Angels)
Muskegon — July 6-8
Muskegon Air Fair (Blue Angels)
Traverse City — July 7 & 8
National Cherry Festival Air Show

Mississippi
Bay Saint Louis — Sept. 1-3
Bay Saint Louis Air Show (Thunderbirds)
Columbus AFB — July 14
Wings Over Columbus AFB Air Show (Thunderbirds)
Meridien — Sept. 26
NAS Meridien Air Show (Blue Angels)

Missouri
Cape Girardeau — July 14 & 15
Cape Girardeau Regional Air Festival
Chesterfield — Aug. 31-Sept. 3
St. Louis County Fair & Airshow
Columbia — May 26 & 27
Salute to Veterans Celebration (Thunderbirds)
Kansas City — Aug. 18 & 19
KC Aviation Expo 2001 (Blue Angels)
Saint Louis — June 30-July 4
Fair Saint Louis

Montana
Bozeman — July 21 & 22
Bozeman Air Show (Blue Angels)

Nebraska
Lincoln ANGB — Apr. 28 & 29
Lincoln ANGB Air Show (Thunderbirds)
Offutt AFB — Aug. 24-26
Thunder Over the Heartland

Nevada
NAS Fallon — June 2 & 3
NAS Fallon Air Show (Thunderbirds)
Reno — Sept. 13-16
Reno Air Racing Association Championship Air Races

New Jersey
Cape May — Aug. 11
Airfest 2001
Lakehurst — June 2 & 3
Lakehurst Air Show (Blue Angels)
Teterboro — June 2 & 3
Wings & Wheels Expo
Toms River — Sept. 22 & 23
Air Show
Toughkenomen — June 3
New Garden Air Show

New Mexico
Angel Fire — July 20-22
Wings Over Angel Fire
Cannon AFB — June 10
Cannon AFB Air Show (Thunderbirds)
Tucumcari — Oct. 10
Tucumcari Rotary Club Air Show (Snowbirds)

New York
Elmira — June 30-July 1
Wings of Eagles Air Show
Niagara Falls — June 30-July 1
Niagara Falls ARB Air Show (Thunderbirds)
Rochester — Aug. 25 & 26
Rochester International Airshow
Syracuse — June 16 & 17
Syracuse International Air Show (Blue Angels)

North Carolina
Concord — May 5 & 6
600 Festival Air & Speed Show
Fayetteville — July 7 & 8
Pope AFB Open House (Thunderbirds)
MCAS Cherry Point — Mar. 30-Apr. 1
Wings Over Carolina (Blue Angels)
Seymour Johnson AFB — Nov. 3
Air Show (Thunderbirds)
Wilmington — June 9 & 10
Carolina Air Expo
Winston-Salem — Sept. 8 & 9
Winston-Salem Air Classic

North Dakota
Minot AFB — Aug. 11
Minot AFB Air Show (Thunderbirds)

Ohio
Cincinnati — June 9 & 10
Blue Ash Airport Days
Cincinnati — Aug. 25 & 26
Lunken Airfest 2001 "A Space Odyssey"
Cleveland — Sept. 1-3
Cleveland National Air Show (Blue Angels, Starfighters)
Dayton — July 21 & 22
Dayton Air Show (Thunderbirds)
Toledo — Sept. 8 & 9
Toledo Air Show

Oklahoma
Muskogee — Sept. 8
Air Show Oklahoma (Thunderbirds)
Oklahoma City — June 29-July 1
Aerospace America International Airshow

Oregon
Portland — June 29-July 1
Qwest Rose Festival (Blue Angels)

Pennsylvania
Latrobe — July 28 & 29
Westmoreland County Air Show (Thunderbirds)
NAS JRB Willow Grove — Sept. 8 & 9
Sounds of Freedom Airshow (Blue Angels)
Pittsburgh — July 7 & 8
Wings Over Pittsburgh
Reading — June 8-10
World War II Weekend

Rhode Island
North Kingstown — June 16 & 17
Rhode Island National Guard Open House

South Carolina
Charleston AFB — May 19
Charleston Air Expo 2001 (Blue Angels, Starfighters)
Columbia — Nov. 2-4
Celebrate Freedom Festival
Myrtle Beach — June 2
Sun Fun Air Show
Shaw AFB — May 10
Shaw AFB Air Show (Snowbirds)

South Dakota
Ellsworth AFB — Aug. 12
Ellsworth AFB Open House (Thunderbirds)

Tennessee
Arnold AFB — June 23 & 24
50th Anniversary, Arnold AFB (Thunderbirds, Starfighters)
Millington (Memphis) — May 12 & 13
Mid-South Air Show (Thunderbirds)
Smyrna — Sept. 15 & 16
Tennessee Aviation Days (Blue Angels, Starfighters)

Texas
Abilene — Sept. 22 & 23
EAA Southwest Regional Fly-In
Beaumont — May 19 & 20
Southeast Texas Regional Air Show
Dallas — June 2 & 3
Dallas Air Show 2001
El Paso — Oct. 13 & 14
Amigo Airshow (Snowbirds, Starfighters)
Fort Worth — Oct. 20 & 21
Fort Worth/Alliance International Air Show (Blue Angels)
Galveston — Apr. 28 & 29
Lone Star Flight Museum Airshow
Goodfellow AFB — July 15
San Angelo/Goodfellow AFB Air Show (Thunderbirds)
Greenville — Sept. 8
50th Anniversary of Majors Field
Houston — Oct. 20 & 21
Wings Over Houston
La Grange — May 11 & 12
Fayette County Regional Air Show & Festival
Midland — Oct. 6 & 7
Confederate Air Force Airshow 2001
Nacogdoches — Apr. 28 & 29
East Texas Airshow 2001
NAS Corpus Christi — Apr. 21 & 22
NAS Corpus Christi Open House (Blue Angels)
San Angelo — July 15
Aviation FunFest (Thunderbirds)
Slaton — May 19
South Plains Airshow

Utah
Hill AFB — June 9
Hill AFB Air Show (Thunderbirds)
Parowan — July 20 & 21
Parowan Southern Utah Air Show

Virginia
Langley AFB — May 12 & 13
Air Power Over Hampton Roads
NAS Norfolk — Apr. 28 & 29
International Azalea Festival Air Show (Blue Angels)
NAS Oceana — Sept. 22 & 23
Neptune Festival Air Show (Snowbirds)
Petersburg — June 9 & 10
Virginia State EAA Fly-In

Washington
Fairchild AFB — Sept. 15 & 16
Aerospace Day 2001
McChord AFB — June 16 & 17
McChord AFB Open House (Thunderbirds)
Pasco — July 28 & 29
Tri-Cities Airshow
Seattle — July 4
4th of Julivars
Seattle — Aug. 4 & 5
Qwest Air Show at Seafair
Tacoma — July 4
Tacoma Freedom Fair Air Show

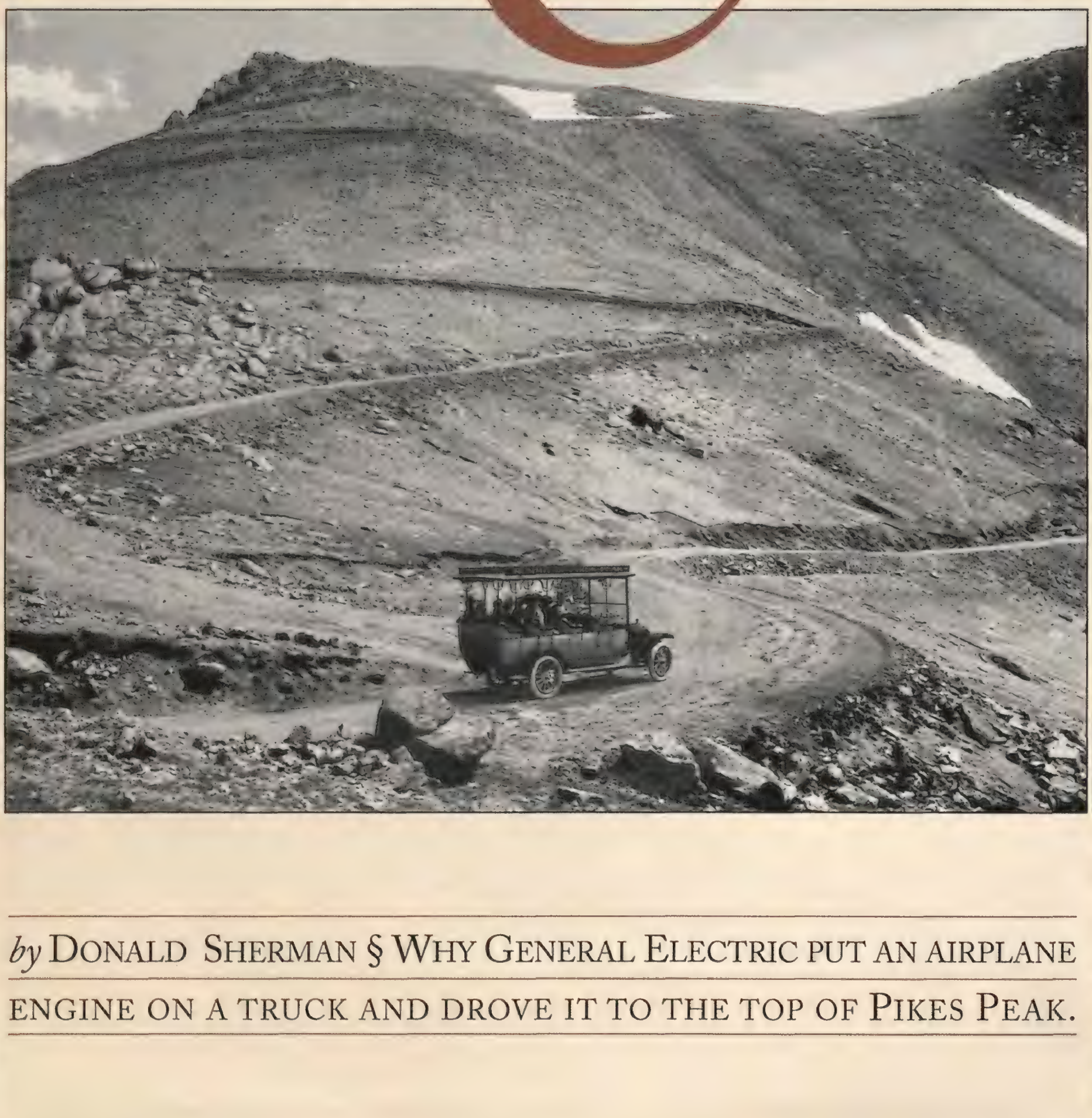
Wisconsin
La Crosse — June 16 & 17
Fourth Annual Deke Slayton Airfest
Manitowoc — June 9 & 10
Manitowoc County Airshow 2001
Oshkosh — July 24-30
EAA AirVenture Oshkosh 2001
West Bend — July 13-15
Greater Milwaukee Air Festival

Wyoming
F.E. Warren AFB — July 25
Cheyenne/F.E. Warren Air Show (Thunderbirds)

Schedule information provided by International Council of Air Shows (www.airshows.org; phone (703) 779-8510). Subject to cancellation, change of date, and change of performers. Check local listings.

AFB	Air Force Base	JRB	Joint Reserve Base
ANGB	Air National Guard Base	MCAS	Marine Corps Air Station
ARB	Air Reserve Base	NAS	Naval Air Station
EAA	Experimental Aircraft Association	USAF	United States Air Force

HILL CLIMB



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by DONALD SHERMAN § WHY GENERAL ELECTRIC PUT AN AIRPLANE ENGINE ON A TRUCK AND DROVE IT TO THE TOP OF PIKES PEAK.

Pikes Peak, the second highest mountain in Colorado, reaches 14,109 feet above sea level. In 1916, race cars began to compete over a road built to the top of the mountain. Each car ran against the clock, and the one that took the least time to reach the top was the winner. The Pikes Peak International Hill Climb is still run every year on the Fourth of July, its basic format unchanged, and the climb is still a severe test for man and machine: The lack of oxygen induces altitude sickness in humans, and engines begin to wheeze as they lose power at high altitude.

In 1918, Sanford Moss, a General Electric engineer on loan to the U.S. Army Air Service and a man with a keen interest in engines, believed he had solved the problem of engine power loss at altitude. In order to demonstrate that his solution would work, he too would find himself climbing Pikes Peak, not to win a race but to perform engine research in the thin air at the summit.

At the time, Moss' immediate problem was that his solution worked too well. He had built a turbo-supercharger, a device that draws energy from an engine's exhaust gases to drive a compressor that pumps an extra charge of air to the engine's intake—*super*charging the cylinders. Moss' device could easily generate the requisite air pressure in the intake manifold of a Liberty test engine, but in U.S. Army tests it caused the fuel-air mixture to ignite prematurely, thereby triggering destructive detonation—a death rattle that could burn or break engine components in seconds. A report filed by two engineers at the Army's labs at McCook Field in Dayton, Ohio, neatly summed up the problem: "When using the supercharger, 470 horsepower [versus a standard Liberty's 420 horsepower] was developed at 1700 rpm. It was, however, difficult to make many tests with the supercharger operating. Even when only subjecting the engine to a small amount of supercharge at this low altitude, the spark plugs failed and numerous other difficulties developed."

SCHENECTADY MUSEUM

The road to the top of Pikes Peak drew tour buses (left) and Sanford Moss (holding a compressor wheel).

Moss, a slight, owlish man with a gray beard and professorial aspect, knew that the only logical way to proceed was to test his turbocharger at altitude. Instead of sending unproven equipment heavenward in the hands of a test pilot, Moss suggested testing the turbocharger on a mountaintop. A crew would mount the test engine on a truck, and then it would simply be a matter of finding a mountain that had a road all the way to the summit.

From the moment when the first airplane rose from the surface of the earth and headed skyward, aircraft engine designers have faced a dilemma: Power fades with a gain in altitude, and eventually an airplane reaches its maximum ceiling—a point at which it can no longer climb. An engine capable of 500 horsepower at sea level puts out only 420 horsepower at 5,000 feet, then 355 horsepower at 10,000 feet. By 20,000 feet, loss of air density has sapped half of the sea-level output. Early aeronautical engineers expressed this dilemma mathematically; devising practical solutions in an era when airplanes were mainly used as attractions at county fairs was not a priority.

But war changes everything, and as soon as the shooting began in World War I, military strategists made for the high ground. In aviation terms, that meant airplanes that could fly higher and faster than one's adversary.

Pretty soon, engineers could read about theoretical solutions in the technical literature. Only nine years after Nicolaus Otto created the first four-stroke-cycle engine in 1876, Gottlieb Daimler, another German inventor, conceived the means to improve it. His patent for supercharging states: "With this engine greater amounts of combustible mixture are delivered into the cylinder and at the same time the exhaust gases are more effectively removed. This is done by means of a pump alongside the cylinder."

In the early 1900s, the supercharger tree sprouted several branches in Europe. Frenchman Louis Renault developed a centrifugal compressor, and in Switzerland, Alfred Buchi proposed using the engine's exhaust gases to spin a turbine wheel and drive a centrifugal compressor plumbed to deliver air to the engine's intake manifold. This bootstrap approach, called turbosupercharging or simply turbocharging, was tested by Buchi's firm, then shelved when success proved elusive.

But the pursuit of efficiency prompted engineers to give turbochargers another chance. The typical piston engine converts only one-third of the energy from its fuel to useful work. Another third is squandered to friction and cooling-system losses, and the remainder is spit out the exhaust pipe as waste heat. A turbocharger could recover some of that exhaust energy.

In the United States, Sanford Moss, a 22-year-old mechanical engineering student at the University of California at Berkeley, had an inspiration during a class on thermodynamics and hydrodynamics: Why not combine the best aspects of internal combustion and steam turbines? A British scientist had patented the same brainstorm a century earlier, but that didn't diminish Moss' enthusiasm for spinning heat into horsepower. In his master's thesis, Moss proposed replacing a locomotive's thumping piston engine with a smoothly humming gas turbine. (He simply picked the wrong vehicle; today many warships are powered by

SCHENECTADY MUSEUM

A North American B-45 jet bomber, in a salute to Moss' role in the development of the turbojet, flew over a 1953 ceremony that dedicated a monument to Moss at the mountain's summit (above). Working at altitude, Moss and his crew had to endure cold and wind. A crude sign near a disassembled turbine section (below) barred cameras—apparently ineffectively.

NASM

turbines.)

In 1901, he began studies and research at Cornell University, and after working for a year, persuaded a spherical combustion chamber to deliver a continuous source of flaming hot energy. Gases from the chamber were directed against a five-inch-diameter turbine wheel; Moss wrote that it was probably the first time a turbine had ever been driven by combustion gases in the United States—or perhaps anywhere.

Moss' 1903 doctoral thesis, "The Gas Turbine, an Internal Combustion Prime Mover," caught the eye of General Electric executives. Formed in 1892 as the amalgamation of the leading AC and DC power companies, GE was responding to mounting consumer demand by constructing ever larger electricity generating and distribution systems. Moss came to GE at the very time when reciprocating engines for power generation were being replaced by more efficient steam turbines.

He worked for four years at GE on gas-turbine reliability, but he couldn't crack the efficiency nut. His best turbine consumed four gallons of kerosene per hour for every horsepower produced, versus only one gallon per horsepower-hour for the day's best reciprocating engines. The materials available in 1907 could not withstand the high temperatures needed to achieve better efficiency in a turbine, so GE shelved its research. But back in Europe, the war was heating things up nicely.

The advent of the Great War focused intense interest on packing more air into engines to gain altitude performance. In Germany, Mercedes, Maybach, and BMW took a brute-force approach, building bigger engines that also squeezed the air-fuel mixture to a greater degree during the piston's compression stroke. Power had to be limited at sea level or the engines would fail structurally, so BMW's 19.1-liter engine, with a compression ratio of 6.4 to one (4 or 5 to one was more typical), had three throttle levers. If all three were opened at sea level, the engine would destroy itself, so the throttles were opened progressively as the airplane climbed. The first-stage throttle delivered 185 horsepower for takeoff at a modest 1,400 rpm. The other two throttles were opened in succession above 6,500 feet, permitting higher engine speeds without the usual loss of power because the engine's high-compression design squeezed more energy out of the thinner air. Rumpler C.IVs equipped with 260-horsepower "over-dimensioned" Mercedes engines and oxygen for their crews flew reconnaissance missions above 20,000 feet, well beyond anyone's reach. The Germans were slower than the British and French at sea level, but at altitude they ruled.

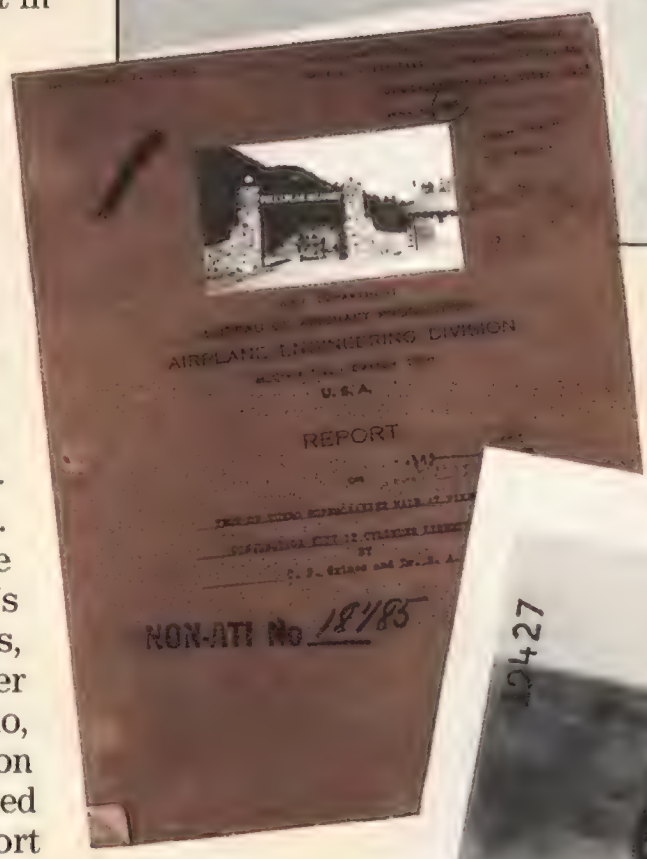
The British government's Royal Aircraft Establishment experimented with reciprocating-piston air compressors

and Roots blowers, which have intermeshing vanes, but the trials bore no fruit. So the RAE concentrated instead on high-speed centrifugal blowers. A BE2C biplane powered by a 537-cubic-inch air-cooled eight-cylinder engine took 35 minutes to climb to 8,500 feet. With an experimental gear-driven supercharger, it climbed 3,000 feet higher. But engine maestro Sam Heron at the Royal Aircraft Factory had doubts, which he expressed in muted terms: "The observer sat forward with his feet under the fuel tank and over the supercharger's gear drive. The gears were quite inadequate and the pinion failed in flight, producing showers of sparks and a feeling of distinct concern."

August Rateau, an enterprising inventor, engineer, and industrialist in France, dusted off a 1909 idea of Alfred Buchi's for a turbocharger and fitted it to SPAD, Breguet, and ALD types with some success. One turbocharged Renault engine improved the rate of climb at 14,000 feet by 15 percent and boosted top speed from 104 to 120 mph. The British evaluated Rateau's equipment, noting a 23 percent improvement in the rate of climb, but suspended research after a catastrophic turbine failure at 13,500 feet.

Rateau's turbocharger caught the eye of the U.S. Army Air Service's technical experts stationed in Paris, and soon investigations were under way at McCook Field in Dayton, Ohio, with an experimental unit running on a Liberty engine. Excessive heat caused persistent failures. A parallel effort initiated in November 1917 by William Durand, chairman of the National Advisory Committee for Aeronautics, was more fruitful. Earlier, Durand had been at Cornell, where he first learned of Moss and his research. He was also well aware of GE's prominence in steam turbines and centrifugal compressors. Durand promptly petitioned GE's president for Moss' assistance.

Engineering drawings of the Rateau device were available, but Moss' GE team had its own ideas. By June 1918, GE's Lynn Steam Turbine Department in East Lynn, Massachusetts, had shipped a prototype to the War Department's Airplane Engineering Division at Mc-



Moss co-authored the final report from Pikes Peak (left), and soon GE's turbochargers, though still crude, were airborne (below). But the big payoff was in World War II, as Jimmy Doolittle, with Moss, would attest (top).

TOP AND BOTTOM: SCHENECTADY MUSEUM; MIDDLE: NASM

Moss was hardly deskbound, posing with the pilot who held the Army's altitude record, J.A. Macready (above, left), and acting as emissary in chief, upper-atmosphere division, for General Electric during a tour of Boeing's "Strato-Trainer" chamber for air crew instruction (below).

TOP: NASM; BOTTOM: SCHENECTADY MUSEUM

Cook Field for adaptation to a Liberty 12 aircraft engine. It was a teenage marriage: an untried turbocharger wed to an engine that one year earlier had been just a glimmer in the War Production Board's eye.

Moss' first turbo consisted of two 10-inch-diameter wheels mounted on a steel shaft turning at 20,000 rpm and supported by bearings at each end that were lubricated by engine oil. One wheel had surfaces that absorbed the blast of the engine's exhaust gases and thereby spun the steel shaft. At the other end was another wheel that drew air in from the atmosphere and compressed it so it could be routed to the engine intake. Engine coolant circulated through a jacket surrounding the bearing on the hot side, where the engine exhaust gas flowed, in order to carry away the heat. Large welded-steel manifolds gathered the exhaust and delivered it to a nozzle box that directed the exhaust at the turbine wheel.

Moss mounted the turbo at the front of the engine so the propeller's slipstream would cool the compressor housing, the nozzle box, and the exhaust manifolds. Valves called waste gates, located at the rear of the exhaust manifolds, could be opened to modulate the flow of exhaust gas to the turbine and thereby control the amount of boost generated.

But in the low-altitude flatlands of Ohio, McCook Field sat at the very bottom of the atmosphere. To test the turbocharger at McCook would mean compressing air that was already thick. The engine wasn't built to tolerate loads imposed by air at high pressure, and every test risked destruction. Then Moss got his idea about climbing a

mountain with the test engine mounted on a truck. And he found a mountain with a road all the way to the top—Pikes Peak, in Colorado.

Together with McCook Field engineer C. P. Grimes and a small crew of technicians, Moss assembled a mobile laboratory: the turbocharged Liberty engine with a huge propeller to absorb the power, a dynamometer to gauge the torque produced, and various support systems. The whole thing was mounted on a Packard motor truck and looked like a carnival contraption.

After a month of preparation and a week-long, 1,300-mile train ride, the mobile lab arrived in Colorado Springs. The crew fired up the Packard, which chugged its way 28 miles up the Pikes Peak Auto Highway to a rocky flat 100 yards in diameter at the top. On September 10, 1918, Moss and his team finally got to work.

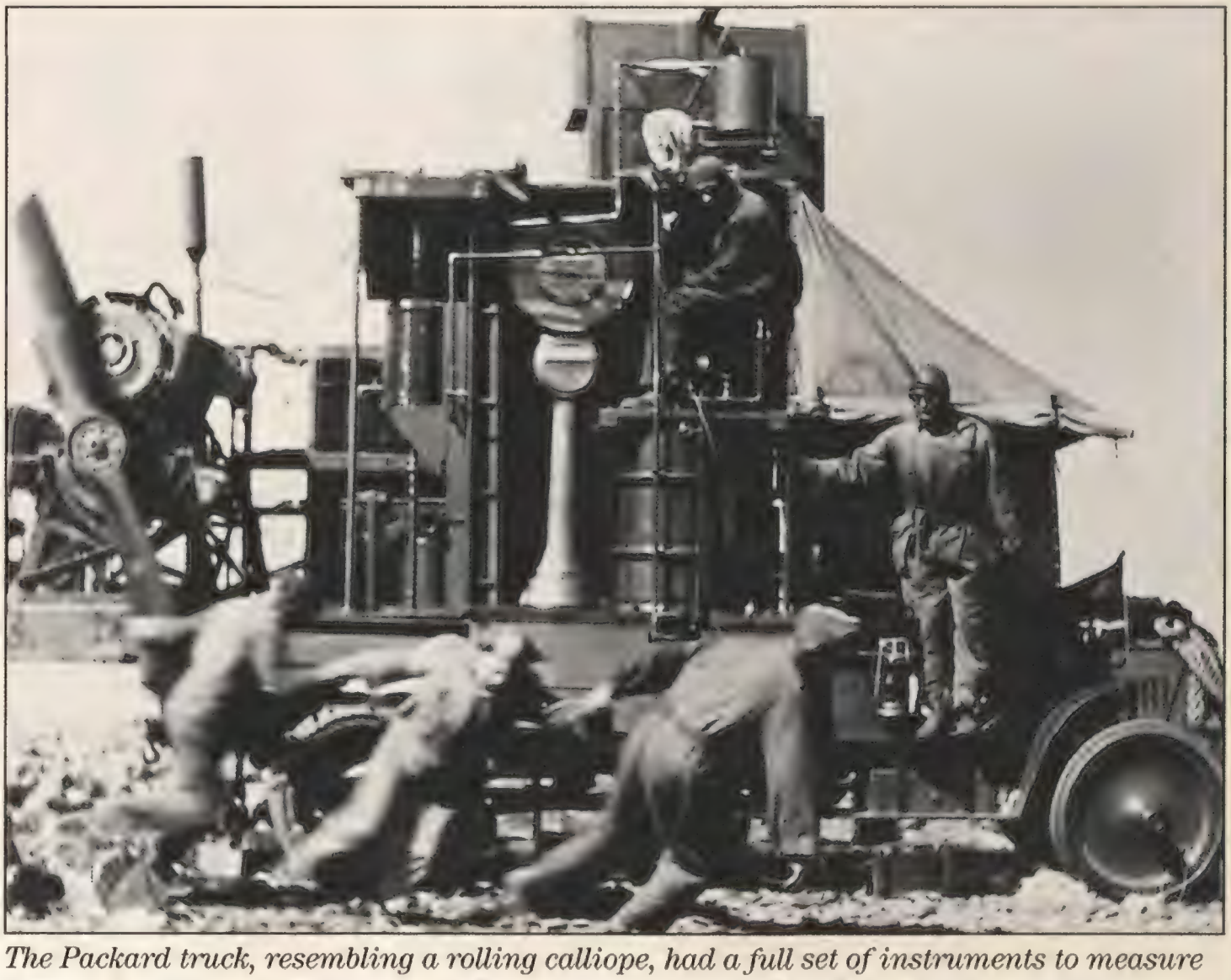
By the time they were done four weeks later, they had made 25 test runs with the turbocharged Liberty. And they had surprisingly few problems: clogged carburetor jets, leaks in exhaust manifold joints, a leak in the compressor housing attributed to casting flaws, some broken turbocharger thrust washers, and some failed stay bolts that were supposed to keep the exhaust manifolds from warping in the heat. The crew performed minor repairs in a small shack at the summit; for major jobs they had to trundle the whole works back down the mountain to Colorado Springs. Before they left the mobile lab every night, they covered it in a canvas overcoat. On many mornings the crew arrived to find their equipment frozen and snowbound. In spite of the wintry conditions, Moss was stoic: "There were many pleasant days when the testing work could be carried on with facility," he noted dryly.

With the supercharger in operation, the nozzle boxes glowing bright red, and the Liberty on the ragged edge of detonation, Moss measured a maximum horsepower of 377—better than the 354 they had achieved at McCook. On the mountaintop and with the turbocharger shut down, the best they could crank out was only 230 horsepower. In his notes from the Pikes Peak test series, Moss conceded that the 377 figure could be held for only 30 seconds; after that the spark plugs failed. The turbocharged Liberty also withstood a four-hour endurance run at 313 horsepower. (Differences between the power measured during these tests and the 400-plus horsepower at which Liberty engines were normally rated could be attributed to propeller losses.)

Moss left no record in his notes of any celebrations the team may have held after the trip down the mountain, but all who participated certainly deserved one. General George Kenney, later an air force commander in the Pacific, boasted in 1942 while touting two frontline fighters with turbochargers, "At high altitudes the Lockheed P-38 and the Republic P-47 can lick anything. There are only two honest 400-mile-per-hour planes in the world, and we've got both of them." Moss and his turbocharger had begun to change aviation history. And GE's expertise with gas turbines left little question as to which U.S. firm should be selected to develop the Whittle turbojet.

On the 50th anniversary of powered flight in 1953, U.S. Air Force Lieutenant General James Doolittle commemorated Moss, who had died in 1947, with a monument atop Pikes Peak. Doolittle cited Moss as an aviation giant, the gas turbine as his brainchild, and the advent of the turbocharger as the birth of true high-altitude flight.

And a final footnote: The current holder of the overall record for the Pikes Peak International Hill Cimb is Rod Millen, who set it in 1994 in an unlimited-class race car that made the run in 10 minutes, 4.06 seconds. Millen's engine was turbocharged.



The Packard truck, resembling a rolling calliope, had a full set of instruments to measure torque, revolutions per minute, and air temperatures within the induction system.

HIGH HONOR

THE ORIGINS OF THE MISSING MAN FORMATION.

BY DANIEL FORD ILLUSTRATIONS BY DAVID PETERS

One morning in July, Lieutenant (Junior Grade) Benjamin Stone finds himself scheduled to fly at a funeral. The site is Arlington National Cemetery, on the outskirts of Washington, D.C. Ben Stone is assigned to VFA-81, which is stationed at Naval Air Station Oceana in Virginia—four hours away as the interstate runs. He'll be part of a four-man formation in McDonnell Douglas F/A-18C Hornets, the pretty bird with two tailpipes, two rudders, and wings so far aft they could serve as elevators.

The casket is supposed to go into the ground at 1130 hours. Stone and his fellow aviators want 30 minutes of loiter time over Washington (they'll circle the metro area while waiting for the funeral to begin), plus 30 minutes for the commute, 45 minutes to saddle up, and 75 minutes to be briefed on the mission. That's three hours, so they start the day at 0830.

Says Stone: "We brief exactly where to hold, where to fly over, what information to expect from the man on the ground, and what to do in various contingencies. For instance, the flight is always briefed as a four-plane, with the third guy pulling up, but we [also] brief a three-plane flyover with a hole in it."

A Naval aviator in Washington will work as ground controller. He went to Arlington yesterday with a GPS receiver to check the grave site and record its latitude and longitude. Stone enters those coordinates into each Hornet's memory.

At 0945, the aviators dress for flight. "Preflight takes five minutes or less," says Stone. "Strapping in and starting up takes about 10 minutes. Most of that time is spent waiting for the INS to align itself." The Inertial Navigation System measures the Hornet's directional acceleration and its rotations in yaw, pitch, and roll; if it knows where the aircraft is when the INS is switched on, it can tell the pilot at any given moment thereafter what spot he has reached above the earth's surface. While the INS sorts itself out, the maintenance crews look for problems outside the cockpit. Sure enough, one Hornet has a mechanical difficulty, and it proves intractable. Plan B is now in effect: VFA-81 will fly the formation with just three aircraft.

In 1999, aviators from Ben Stone's squadron drew three of these funeral assignments: flying the Missing Man formation for Admiral Donald D. Engen, director of the National Air and Space Museum; for the repatriated remains of a PBY Catalina crew from World War II; and for Senator John Chafee of Rhode Island.

Military guidelines authorize flyovers for "dignitaries of the armed forces and

the federal government." But in November 1999, four Air Force F-16 Falcons made a flyby at a Texas A&M football game to mourn the Aggies killed while building a pre-game bonfire of heavy logs, which collapsed. Another Air Force flyover memorialized the students shot at Columbine High School in Littleton, Colorado. So how did the youngsters get to be dignitaries? "The events in question were deemed public affairs events," says an Air Force public affairs officer. In short, the military ignores its guidelines if the grief level is high enough.

And guidelines don't apply to civilian aircraft. John F. Kennedy Jr. got a salute from German-built Extra 300s at the Experimental Aircraft Association fly-in at Oshkosh, Wisconsin. Last year "Peanuts" cartoon creator Charles Schulz got a flyover by World War II-era fighters at his funeral. And out in California, the Memorial Flights company will fly the Missing Man for anyone with the ability to pay for it: $1,800 for four T-6 Texan trainers, $3,600 for three World War II fighter aircraft, within 50 miles of Chino.

In short, the Missing Man formation has become an American tradition—cliché, if you prefer. And like Coca-Cola, McDonald's, and "okay," it has spread around the world. When World War II ace Colonel Lauri Pekuri died last year, Finnish air force F-18s flew the Missing Man at his funeral.

Curiously, for the first half of the history of flight, the now-ubiquitous formation was seldom seen. Oh, there was the occasional flyby: British squadrons on the Western Front in World War I sometimes overflew their airfields after combat, so the men on the ground could count the number of surviving aircraft, and King George V got a mass flyover at his funeral in 1935. Then there was Major General Oscar Westover, head of the U.S. Army Air Corps. When he was buried at Arlington in September 1938, no fewer than 50 fighters and bombers flew overhead, and the formation had a "blank file," or empty row, of half a dozen aircraft—almost, but not quite, a Missing Man.

The first approximation of today's Missing Man appears to have occurred in 1931, when the May 22 edition of the St. Paul, Minnesota *Pioneer* wrote about the funeral of Charles W. "Speed" Holman, operations manager of Northwest Airways. Reported the *Pioneer*: "During the services in the temple, a broken formation of four 109th Air Squadron planes kept vigil from above. As they droned high they kept a gap in the flight. The vacant place was for 'Speed.' "

By the end of the Korean War, the Missing Man had entered the inventory. In April 1954, Air Force General Hoyt Vandenberg was buried at Arlington with "several departures from the prescribed Special Military Funeral," in the words of *The Last Salute*, an astonishingly detailed 1971 book written by B.C. Mossman and M.W. Stark on the subject of graveside honors. The traditional horse-drawn artillery caisson was missing. Instead, Vandenberg got "a flyover of jet aircraft with one plane missing from the formation."

> "We get a three-minute warning from the guy on the ground and start heading that way. Then we accelerate just at the last second to be extra fast at the grave."

Also in 1954, Captain Joseph McConnell Jr. was testing a modified North American F-86 Sabre at Edwards Air Force Base in California when he ran into trouble and was killed trying to save the airplane. This was in an era when Hollywood and the Pentagon were a team, and Warner Brothers immediately cranked out *The McConnell Story*, a film featuring Alan Ladd, June Allyson, a sonorous Air Force general, and not one but two Missing Man formations. The first takes place while the Korean War is hotting up in the summer of 1950. Ladd and Allyson are inspecting a homesite in Apple Valley, California, when suddenly a squadron of F-86s flies overhead in three flights of four. The leader of the second flight pulls up and away. Asks Allyson in her husky, housewifey voice: "Why is that plane leaving the formation?"

Ladd: "You heard about the accident this morning?"

Allyson: "Yes."

Ladd: "It's the flyby for Lieutenant Gordon. See that open slot? That's the position he used to fly. It's called the [pause for effect] Missing Man formation." The second occurrence is at Edwards, when the squadron leader comes over to tell Mrs. McConnell that her husband has bought the farm.

Today, the Missing Man is usually flown as a finger-four, a combat formation developed by the Germans and soon adopted by all sides in World War II.

The flight leader is at the point of the arrowhead, with his wingman following and to the right, as seen from below. Occupying the same position on the flight leader's left is the second-element leader, who in turn has a wingman behind him and to the left. In short, the formation is a "V" with the left leg longer than the right.

The leader of the second element is the Missing Man. Either this airplane is absent altogether, or it leaves the formation in a spectacular pull-up. In the case of the U.S. Air Force Thunderbirds, the U.S. Navy Blue Angels, and some civilian aerobatic teams, the Missing Man trails a plume of smoke to emphasize the pull-up, but smoke is never used at a military funeral.

Ben Stone and his two squadron mates take off from NAS Oceana at 10-second intervals. They join up on the run, climb to 16,000 feet, and scream toward Washington at 460 mph. About the same time, their ground controller is getting in his car and driving out to Arlington with a hand-held radio. Says Stone: "Along the way, we will talk to Oceana Departure, Norfolk Approach, and Washington Center, who will eventually switch us off to Andrews Approach, who will descend us down to about 3,000 to hold over Andrews awaiting the call. Andrews' tower is familiar enough with flyovers at Arlington that we don't need to ask for any special clearance."

The Hornets are now 20 miles south-southeast of Arlington, communicating with Andrews on a special discrete frequency that's free of other radio traffic. At the cemetery, the ground controller is tuned to the same frequency. "Once we check in on the discrete, Andrews knows where we are, but it is the guy on the ground who is really controlling us," says Stone. "He'll tell us that the funeral is dragging on, or it's almost over, or whatever. Usually, we will plan to fly at a suitable fast speed divisible by 60. That way you know how many miles per minute you fly and it makes it easy to do the math." If the controller wants the Hornets over the grave in three minutes, the arithmetic goes like this: 20 miles divided by three minutes equals...well, call it seven miles per minute, or 420 mph.

"We get a three-minute warning from the guy on the ground and start heading that way," says Stone. "Out of the turn, we take our exact positions [for the formation] and hold them the rest of the way. Ideally, we fly a little bit slower than necessary, so we're on a pace to be just a little late. Then we accelerate just at the last second to be extra fast at the grave."

If they've misjudged and find themselves coming along too fast, they slow down and do shallow turns to kill a few seconds. "The man on the ground can see us more easily than we can pick out the grave site, and he gives last-minute heading changes of a couple of degrees to talk us directly over the funeral," says Stone. "He also gives us a five-second countdown so we know when we pass over it. That way, the Missing Man can peel up out of the formation right on cue."

Today, of course, there are only three aircraft, and the Hornets sweep over the casket with a gap where the Missing Man would have been. Arlington National Cemetery lies inside the sprawl of metropolitan Washington, D.C. Out of deference to the folks living on the hill overlooking the cemetery—and also the Federal Aviation Regulations—the flyover is done at an altitude of 1,000 feet. The Hornets are, however, excused from the regulation that limits low-flying aircraft to a speed of 200 knots.

Later, one of the mourners recalled: "The Hornets made their characteristic sort of quiet, high-pitched whine. They approached quickly, and then it was over in the blink of an eye."

It is probably a moment, however, that those standing by the grave will remember for some time.

Resto

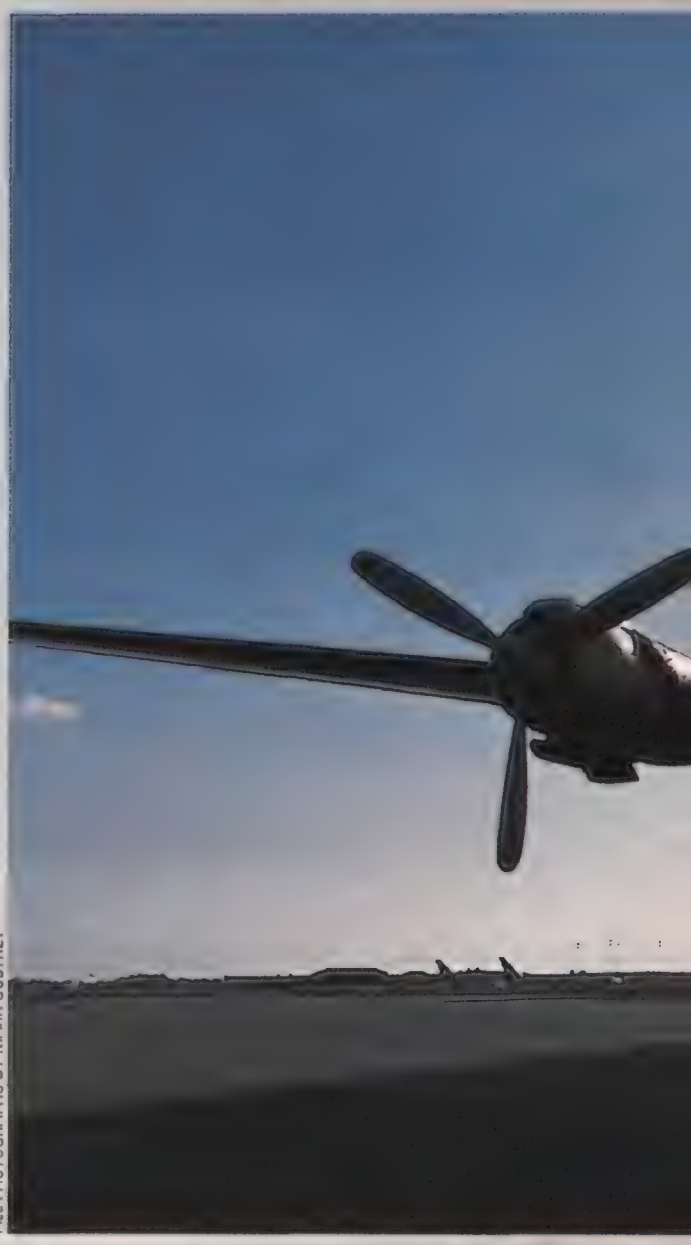
Grande Dame | Lockheed L-1649A Starliner

There were Boeing Stratocruisers, Douglas DC-6s, DC-7s, their big radial engines belching smoke, and, of course, the timeless DC-3. But among the handsome airliners on the taxiway in the 1940s and 1950s moved the Lockheed Constellation, shapely as a Bettie Page pinup.

During their heyday, more than 800 Connies plied air routes around the world, but today, only about 25 remain. Just five are airworthy, but a sixth, an L-649A Starliner located at Sanford Airport outside Orlando, Florida, will soon join that select group. Owner Maurice Roundy and a handful of volunteers are in the final stages of preparing the old classic to fly again.

When the work is complete, the Connie will be awarded a ferry certificate, which will enable it to be flown, but in good weather and away from populated areas only. Roundy is looking for a buyer or corporate sponsor who can afford the aircraft's $250,000 asking price, completely restore the Connie, and fly it on the airshow circuit. But even after the Starliner takes to the air again, it will still require an estimated $750,000 of work to make it ready for continual operation.

Roundy owns two other Constellations, both located in Maine and awaiting refits and new owners. All three of his aircraft are L-1649A Starliners—the Constellation's final version—which first flew in 1956. Trans World Airlines, Lufthansa, and Air France bought a total of just 44 1649s, and the type enjoyed a few years of service on prestigious transcontinental routes before de Havilland Comets, Boeing 707s, and Douglas DC-8s relegated piston-driven aircraft to hauling cargo.



ALL PHOTOGRAPHS BY MARK GODFREY

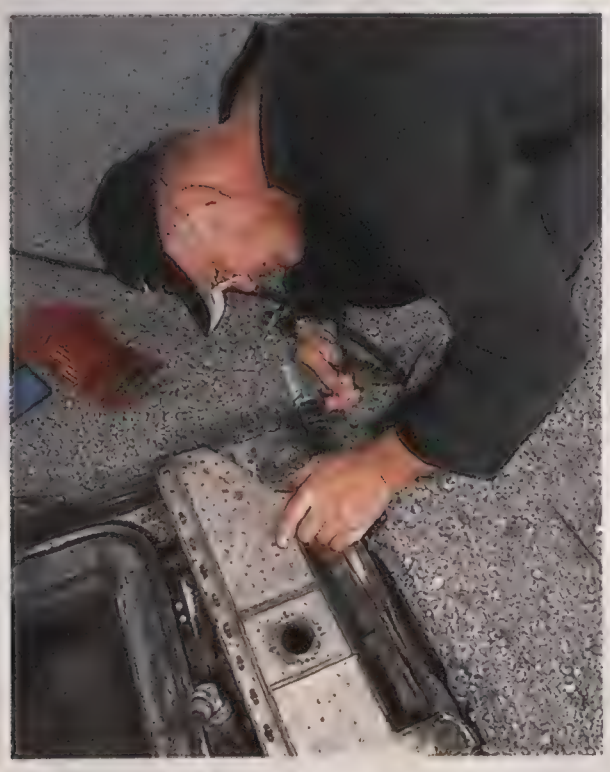
Maurice Roundy (above) hopes a new owner will restore the Starliner's once-plush cabin, now filled with tools, manuals, and drums of engine oil.

Roundy's Florida-based Constellation was a Lufthansa veteran and was configured for comforts unheard of in the current era of salted peanuts and knees in the seatback. Talk about legroom: As part of the airline's Senator Service, the aircraft—capable of holding 86 passengers in standard configuration—was fitted with only eight first-class seats, 18 deluxe-class seats, and four beds. On each transoceanic flight, 30 lucky Senator Service passengers were pampered with gourmet meals served on fine china.

With its gutted interior, N974R is a long way from its former glory as an international airline flagship, but the old Constellation waits patiently for new schedules to keep.

—John Sotham

r a t i o n

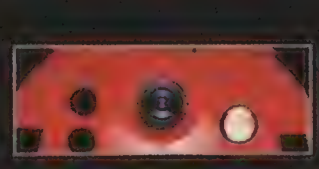


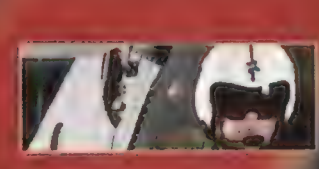
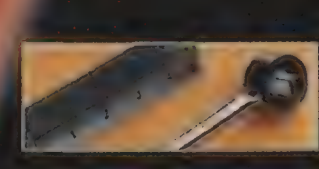
Roundy (left) works on an air scoop, one of thousands of details he must attend to as the Starliner awaits its ferry flight and new horizons (top). The engineer's panel (above) monitors the vital signs of four Wright 998 Turbo Compound engines: fuel mixture, manifold pressure, and cylinder temperature.

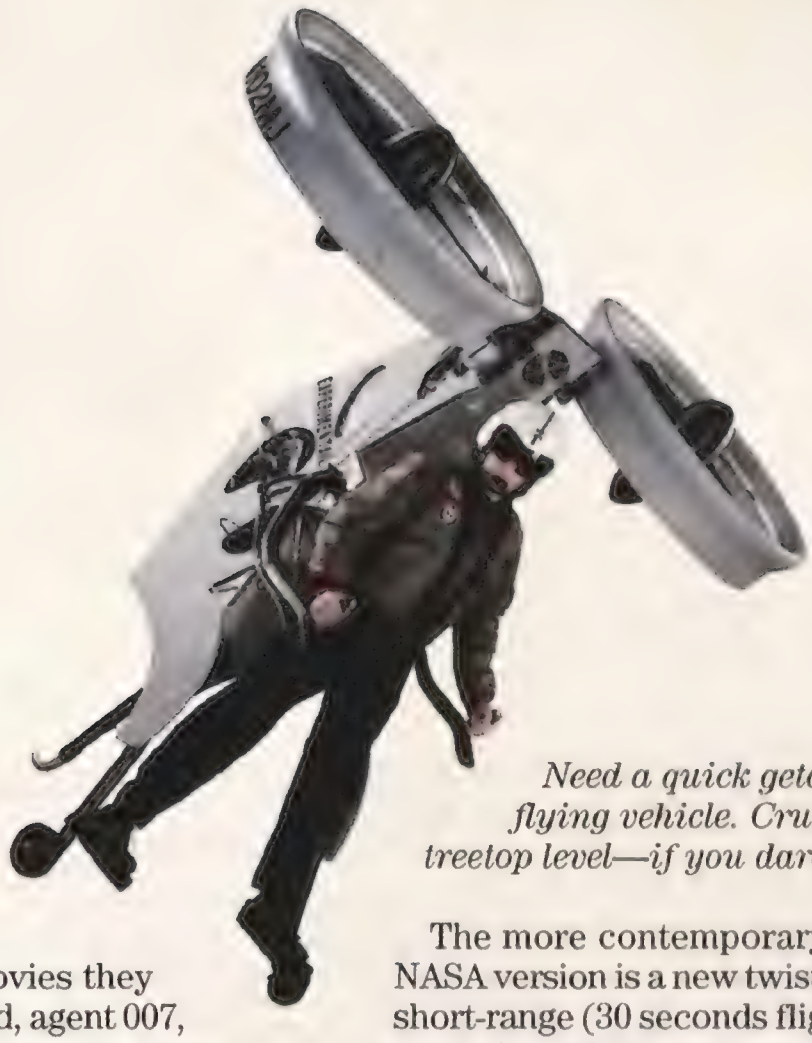
Getting the props turning—and reversing—results in skinned knuckles beneath the Connie's gull-wing cowlings (above).

WHEN THE JOB DEMANDS INGENUITY, NASA

ENGINEERS WHIP UP GADGETS WORTHY OF JAMES BOND.



Need a quick getaway? Try the SoloTrek flying vehicle. Cruise at 70 mph at treetop level—if you dare.

BY ERIC ADAMS

James Bond has Q. NASA has John Vranish, Gregory Dorais, and Sarath Gunapala.

But we'll start with Q. In Ian Fleming's famous books—and the even more famous movies they spawned—suave British super-spy James Bond, agent 007, often relies on complex gadgetry as much as his own wits to get the job done. That gadgetry comes from a clever, eccentric engineer with a single-letter code name. Q spends his days in the basement of a government building in London overseeing the development of such novelties as jet packs, rocket-firing 35-mm cameras, miniature radio transmitters, homing beacons hidden in buttons, laser guns, X-ray devices as small as a cigarette case, exploding alarm clocks, and a particularly wicked umbrella whose ribs contain razor- sharp knives that slam into the holder's neck when water hits the umbrella.

NASA gadgeteers—Vranish, Dorais, Gunapala, and dozens of other engineers in NASA centers around the country—are tasked with much less lethal assignments—but their work can be just as fascinating. Softball-sized spherical robots, hand-held infrared cameras, robotic snakes, and personal flying vehicles are just a few of the marvelous devices that would make Q envious and serve as perfect aids for intrepid international spies.

And like the Bond gadgets, the ones in this batch often require as much skill to use as they did to design. So as we tour NASA's labs for a look at their most wondrous little inventions—some stand-alone, some part of larger systems—remember the admonishment of the often-exasperated Q: "Pay *attention*, 007!"

SoloTrek XFV

James Bond would love this one: The SoloTrek XFV, a ducted fan-powered personal flying machine. Indeed, Bond has been down this road before. In the opening scenes of 1965's *Thunderball*, the agent makes a noisy getaway in a Bell-Textron Jet Pack on loan from the U.S. Army.

The more contemporary—and much quieter—NASA version is a new twist on the short-lived, very-short-range (30 seconds flight time) jet pack. Using unique ducted-fan engines, the SoloTrek will carry commuters, soldiers, and other adventurers for up to two hours at 70 mph.

SoloTrek is actually the brainchild of Michael Moshier, president and CEO of Millennium Jet, Inc., of Sunnyvale, California. Moshier's team is getting a technology boost from the engineers at NASA's Ames Research Center in California through a cooperative agreement. "Our company formed in 1996, and I was pulling in talent to make the idea work," Moshier, a former Navy fighter pilot who served in Vietnam, recalls. "NASA saw our Web site and approached us about the project. There's no money changing hands, but we get lots of resources and time and energy, and they can use the test results in other projects."

Having completed wind tunnel tests at Ames, the SoloTrek is now undergoing high-power static thrust testing. Ultimately, the heart of its success will be its finely tuned, highly efficient ducted fans, which are powered by a two-stroke, 110-horsepower piston engine that will eventually be replaced with a small turboshaft jet engine. NASA engineer William Warmbrodt, head of the aeromechanics branch at Ames, says that new lightweight materials have permitted significant advances in the ducted-fan technology developed in the 1950s. "The duct system alters the airflow into and out of the fan to reduce the amount of energy that is lost in the wake and thus, along with the lighter components, lower the amount of power necessary," he says. "With vanes positioned in the outwash, we have a very maneuverable aircraft."

The first fully operational SoloTrek built will go to the Defense Advanced Research Projects Agency, which has provided $5 million in development funding and has an ob-

MILLENNIUM JET, INC.

vious interest in acquiring more of the vehicles for special forces assignments. Moshier also has heard that the producers of the James Bond films are keen on it. "We expect to hear from them very soon," he laughs.

Hand-Held Infrared Video Camera

For decades, high-performance infrared imaging has languished at the same level: big, expensive, and hard to make. But NASA's engineers seem to have cracked the code with the technology behind this handy infrared video camera. The miniature marvel can spot people trapped in burning buildings, detect breast tumors, help pilots see at night, and even identify rockets by their plumes.

The camera uses a newly developed array of highly sensitive infrared detectors known as QWIPs—quantum-well infrared photodetectors—that cover longer wavelengths than could be seen with previous detectors, says team leader Sarath Gunapala of the Jet Propulsion Laboratory in Pasadena, California. While most people are aware of the

Food and Drug Administration recently approved the BioScan System, developed by OmniCorder Technologies, for the early detection of breast cancer. BioScan exploits QWIP's ability to discern minute temperature variations—indicators of tumor development—during high-speed, high-resolution imaging. Other possible uses include law enforcement, search and rescue, and, of course, covert spy operations in distant, romantic settings.

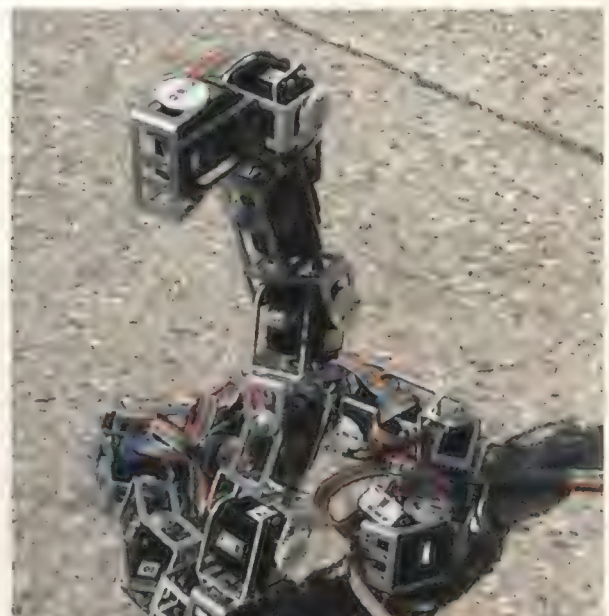
Snakebot

If Q had designed this robotic snake, he would probably just have it slither up to an enemy's Mercedes and explode. NASA's vision is a bit more ambitious: explore new worlds and inspect spacecraft inside and out.

The task is difficult. Serpentine robotics is among the hardest—and thus least researched—fields. "A robotic snake is a wide-open engineering problem," says Charles Neveu, an Ames contractor employed by QSS Group, Inc. "We found that *very* attractive."

LEFT, CENTER: NASA/JET PROPULSION LABORATORY

Bond—who loves quips—could put this QWIP infrared camera to work finding the bad guys. But it's probably better used exploring space.



NASA/AMES

Snakebot shows off its rearing capabilities. Poison darts, anyone?

night vision capabilities of near-infrared imaging, far-infrared imaging is much more useful. Objects glow brightest in the longer-wavelength far infrared, and the atmosphere in this part of the electromagnetic spectrum is transparent, allowing for clearer ground-based astronomical observations and space-based surveillance of Earth.

JPL's Center for Space Microelectronics Technology and a Raytheon subsidiary called Amber developed the technology, which, compared with traditional infrared devices, is far less expensive because the QWIPs are fabricated with the same mature techniques used in cellular telephones and lasers for compact disc players. This has generated considerable interest in the private sector. "In the past, people haven't used infrared much because the cameras were these huge things," Gunapala points out. "So we knew when we started to make a small camera that there would be other commercial uses."

Foremost among these are medical applications. The

Neveu, a computer scientist who is working on the project with leader Silvano Colombano, explains that serpentine movement is useful in space exploration because it allows for a variety of tasks: burrowing into the ground or crawling through the labyrinthine innards of spacecraft to inspect hard-to-reach parts. Wheels and legs are ineffective in microgravity, he points out, but the ability to coil around pipes and slither through narrow passageways is very handy. "A snake is basically one long prehensile tail, so a robotic snake can swing like a monkey from one structural member to the next," Neveu says.

Snakebot now exists only as a prototype, powered by off-the-shelf hobby motors at each joint and formed from plastic bolted and glued together ("It cost us less than $500 and works great!" Neveu says). A second prototype under construction incorporates sensors to tell when the robot is touching things and at what angle each of its joints is positioned—crucial for maintaining precise control. The sci-

"A robotic snake is a wide-open engineering problem. We found that very attractive," says Charles Neveu, a contractor at the Ames Center.

NASA/AMES (2)

Everyone should have a Personal Satellite Assistant, a little sphere packed with sensors, propelled by fans, and always at your beck and call.

entists programmed the first prototype to execute undulatory, inchworm, and sidewinder motions.

The challenge they now face is getting Snakebot to go where they want it to. "Thrashing around will move the snake, but if you want to do anything specific it gets really hard really fast," Neveu says. The answer: software simulation. The team will devise a computerized snake, environment, and control system, then introduce learning schemes and evolvable intelligence. Once the simulated Snakebot learns how to crawl around, they'll transfer the technology to the real snake.

It probably *would* be easier to just make it creep up somewhere and explode.

Personal Satellite Assistant

This little red ball—the Personal Satellite Assistant—is a cross between the all-knowing computer HAL of *2001: A Space Odyssey* and the small floating sphere that shoots tiny laser blasts at Luke Skywalker in *Star Wars*—although the PSA's designers don't expect their invention to go berserk and fire at astronauts.

What they do expect is that the PSA will help astronauts working aboard the International Space Station. Engineers Yuri Gawdiak and Gregory Dorais are in charge of developing the PSA at the Ames center. There, the PSA prototype is being put through a variety of tests that will lead up to eventual usage aboard the ISS.

Dorais explains that, for starters, the PSA will be able to monitor environmental conditions aboard the station, providing a backup check to the station's sensors. "If they lost pressure or power, or if there was a fire and they didn't know what toxic gases were released and whether or not they should sleep, the PSA would monitor that for them and function independently of the ship's systems," Dorais explains.

The PSA maneuvers with small fans and incorporates stereo cameras and display screens that will help astronauts monitor multiple experiments simultaneously. It can be used to communicate with other astronauts as well as external computer databases.

The next challenge is getting the PSA to understand voice commands and behave independently. "We want to get beyond the current technology to dialogue management, and we're using some pretty high-level autonomy software to control its movements and actions," says Dorais, who hopes the PSA will be ready for service by 2006. "It's quite a bit like science fiction."

Click-less Wrench

Gadgets don't have to do startling things to be clever. This award-winning little wrench is a case in point: Though it

appears to be an ordinary hardware store ratchet, it represents a significant leap in mechanical technology. John Vranish, an engineer at NASA's Goddard Space Flight Center in Greenbelt, Maryland, conceived of it to solve a sticky problem astronauts might encounter while assembling hardware in orbit. "We've had 'clickless' ratchets before, but they don't work reliably in space," Vranish says, "because the greases used in these tools often cause slippage and eject gases that can get all over things like optics." And ratchets that do click require so much travel between "clicks" that it's almost impossible to use them in tight spaces.

Vranish's wrench incorporates something known as a 3-D sprag, which permits the wrench to travel in only one direction through a wedging action. "A 2-D sprag is basically a roller which locks in one direction and slips in the other," he explains. "A 3-D sprag is like a disc with wedges and contacts on the surface of those wedges. It locks up better, is more compact, and can withstand more force. It is a fundamentally new mechanical component."

No ordinary wrench, but soon you'll be able to buy it in an ordinary hardware store.

LEFT: NASA/GODDARD; RIGHT: NASA/JOHNSON SPACE CENTER

Robonaut's ability to duplicate human movement promises infinite usefulness in space.

This technology—which also works better than conventional ratchet wrenches in tight spots on Earth—makes ratchetless wrenches possible. NASA is negotiating with several well-known companies that want to market the wrench for industrial and consumer applications. So this is one gadget that James Bond will be able to pick up at Home Depot.

Robonaut

Robots are slowly beginning to look the way we expect them to—that is, like us. Robonaut, being developed by engineers at NASA's Johnson Space Center in Houston, is heading seriously in that direction—and for some very good reasons. "All the robotic devices we've flown on the space shuttle so far have been very large-scale manipulator systems and require specialized [fixtures and attachments] to be utilized," says Chris Culbert, head of the robotic technologies branch at JSC. "But most of NASA's vehicles are designed around humans for maintenance. So we set out to design a human-form robot." This, he says, saves NASA time and money, since engineers can eliminate robot-specific attachments and astronauts can be assisted by robots with a greater range of access and activity.

The current prototype has two arms, two hands, a torso, and a head. It is controlled by a human wearing a virtual reality hood-and-glove system, though its designers hope to eventually give it more autonomy. Their biggest challenge to date, however, has been equaling the engineering of the human hand and simply getting the robot to do what a human wearing a spacesuit glove can do. "That was our first real breakthrough," Culbert says. "We were shrinking existing technology to create a human-sized hand that has all the same movement and strength."

Robonaut will most likely be placed into service aboard the ISS or the shuttle, where its pogo-like leg can be attached anywhere on the vehicle—rather than at a single point as with robotic arms—to conduct repairs, install equipment, and assist with experiments while being controlled by an astronaut inside. For planetary exploration, Robonaut can be mounted on a wheeled rover, like a centaur. Looking even farther into the future, Culbert expects to one day complete the humanoid form. "We're facing some interesting balance and strength challenges," he says. "We as humans have a slew of systems that allow us to lean over and pick something up, but Robonaut will need very advanced software and control systems to do that. Maybe someday, though."

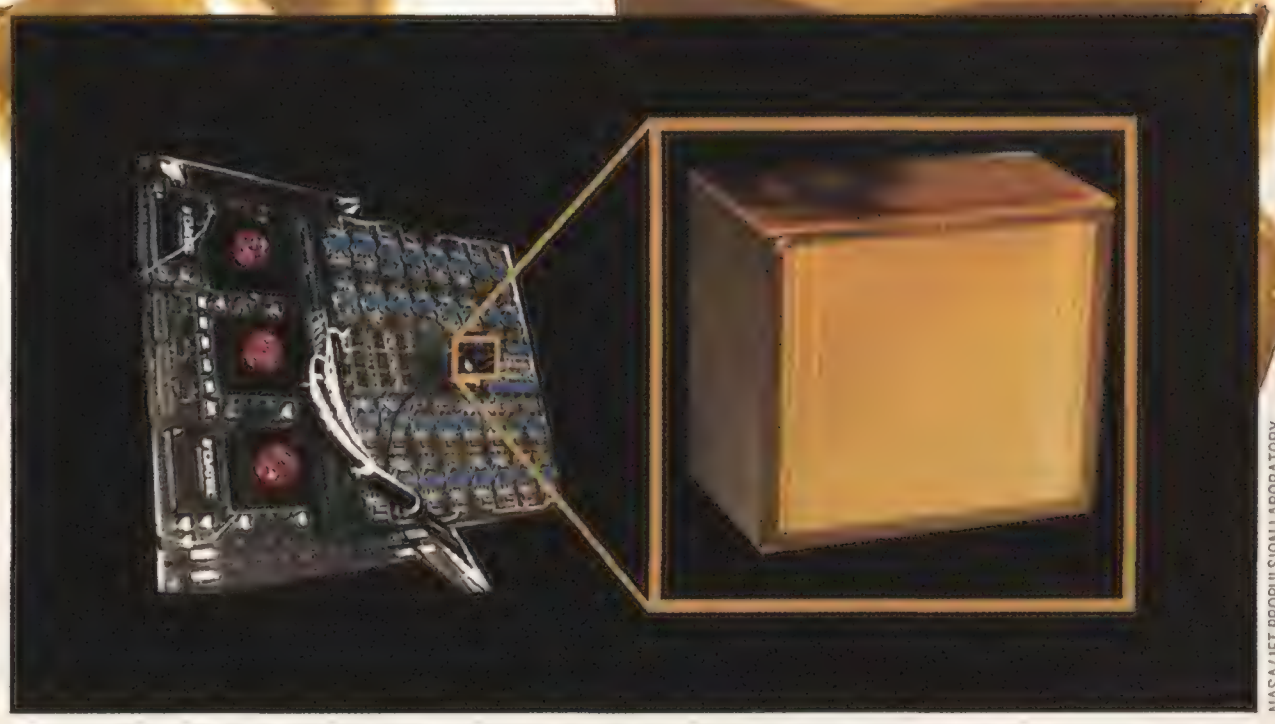
Object Recognition Processor

Like the Johnson Space Center engineers who modeled Robonaut after the human form, computer scientists at the Jet Propulsion Laboratory turned to the human model for their latest effort—though they looked more inward than out. Their Three-Dimensional Artificial Neural Network (3DANN) processor models the neural networks of the human brain to allow machines to identify objects practical-

"We as humans have a slew of systems that allow us to lean over and pick something up, but Robonaut will need very advanced software and control systems to do that," says Chris Culbert, head of the robotic technologies branch at Houston's Johnson Space Center.

LEFT, TOP: NASA/JOHNSON SPACE CENTER

Human-size hands are just right for wielding tools (above and top).



NASA/JET PROPULSION LABORATORY

This tiny cube can recognize everything from missiles in flight to landing sites—and in the process consume less power than your desktop computer.

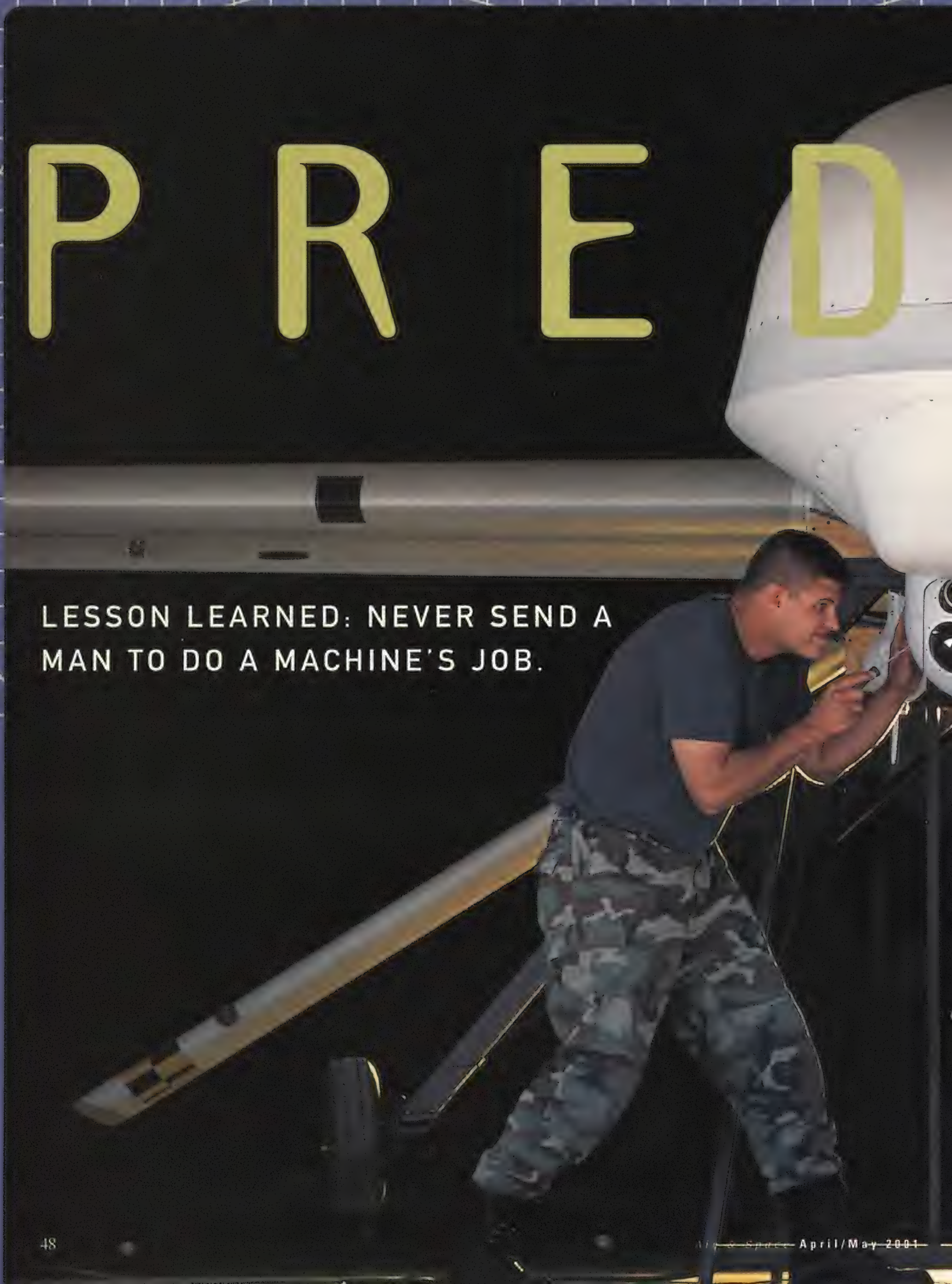
ly as well as people do. "This little camera system can very quickly zoom onto specific features of objects to recognize them," says JPL computer scientist Anil Thakoor. "With the human eye, for example, you will not really recognize a car by its actual measurements, but your brain will recognize the concept of a car. That is what this cube is good at: recognizing objects by looking at their inherent qualities."

The sugar-cube-size processor can execute one trillion operations per second while consuming only 8 watts of power. This performance is several orders of magnitude greater than the capabilities of state-of-the-art desktop computers, which deliver about one billion operations per second while consuming 200 watts of power.

This means that weight- and power-sensitive spacecraft will be able to navigate visually and identify landing sites and obstacles on their own, without wasting time—and money—going back and forth with NASA controllers on Earth. Furthermore, planetary robots and rovers will be capable of autonomous selection of scientifically interesting features to study. Back home, the camera has already proven itself able to identify a cruise missile in various orientations, scales, and lighting conditions and amid a high level of background clutter.

All of these compact contraptions arise from the unique demands of challenging tasks in utterly inhospitable environments, and they require innovation, imagination, and pure technological prowess—a list that could call to mind only one federal agency. "People usually ask me how we approach things. If there's a tough problem, we need to get outside the box and think of an innovative approach that will work," says Goddard's John Vranish. "We'll dig in and find a way to do it. In the end, it has to be on budget and on time, but it also has to be superior. It has to work as required and at *all costs* not fail."

Q would wholeheartedly agree.



LESSON LEARNED: NEVER SEND A MAN TO DO A MACHINE'S JOB.

by LINDA SHINER *Photographs by* CHAD SLATTERY

In the video several dark cars and a beige van have stopped on the side of a road, and five people are walking up to the first car, perhaps to check directions with its driver. Why else would they have stopped in the middle of nowhere? Because this video is being shot from an aircraft flying at maybe 10,000 feet, I'm surprised at how well I can see these people: I can make out four men, two with jackets, and a woman in a dress. It's as though I'm looking down from the rooftop of a building.

It's spellbinding to watch people who don't know they're being observed, and I want to keep watching, but the camera, part of the instrument payload on an RQ-1 Predator unmanned aerial vehicle, moves on. The UAV is flying a routine mission from Tuzla, Bosnia, launched by the U.S. Air Force 15th Reconnaissance Squadron. This little caravan is obviously not what the Predator's masters are looking for.

Ground crew members tend the all-seeing eyes in the nose of the RQ-1 Predator, the U.S. Air Force's most advanced unmanned aerial vehicle.

"It's very rare that we even see people," says Senior Airman Heather Hunnel, 23, a sensor operator who directs the Predator's cameras and radar. "Mostly we see houses. Lots of houses. With no roofs."

We are inside the Predator's ground control station, a 30- by eight-foot structure very much like a semi-trailer. Hunnel and two colleagues have recently canceled the day's mission because of thunderstorms. The Predator has already returned to Eagle Base, a U.S. Army installation in Tuzla, and we're watching some video it recorded earlier. The same images were sent in real time by satellite and transoceanic cable to the Joint Worldwide Intelligence Communications System node at Ft. Belvoir, Virginia. From there they were relayed to 34 U.S. and allied command centers—like it says, worldwide.

What the Predator was looking for that day (or any day) is classified, but to put it simply, the airplane looks for trouble. The 15th Reconnaissance Squadron was in Bosnia to support SFOR, a "stabilization force" of 20,000 NATO troops sent there to serve as a buffer between the Muslims and Serbs

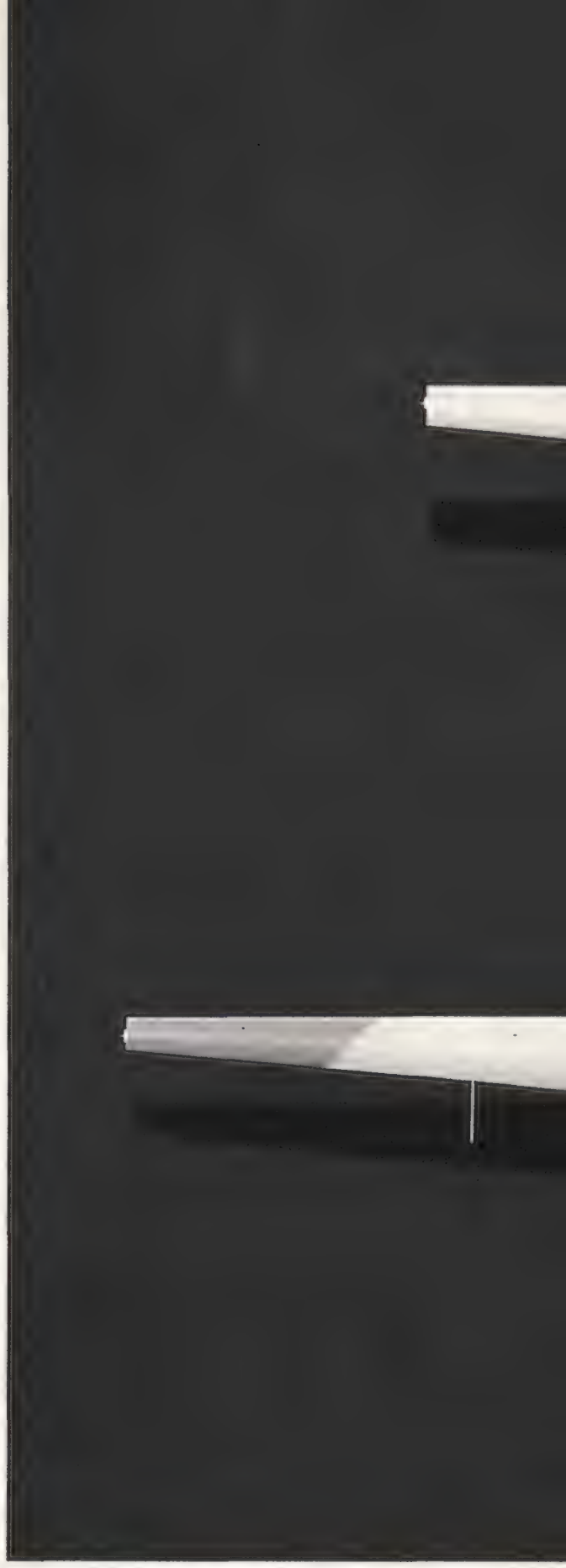
CENTRAL INTELLIGENCE AGENCY

who waged war for three and a half years. They also support KFOR, a similar force protecting civilians in Kosovo, 1.5 million of whom were driven from their homes by Federal Republic of Yugoslavia forces. It's up to SFOR and KFOR to see that all sides observe the cease-fire agreements. And the Predator has been one of their best ways to see.

The $3.2 million craft carries 450 pounds of imaging sensors: a fixed video camera in its nose so its pilots can see where it's going, and two daylight TV cameras, one with a 955-mm zoom lens, in a stabilized gimbal under its chin that steadies the lenses. It also carries an infrared camera with three telephoto lenses plus a synthetic aperture radar, which can penetrate clouds and spot vehicles hidden under trees; the return from metal is different from that of leaves. The radar builds a cumulative topographical map of the ground that looks like a grainy black-and-white photograph.

Because the Predator is small, white, and almost invisible in the sky, people don't realize they're being watched. Its 80-horsepower four-stroke Rotax 912 engine is virtually silent at altitude but as annoying as a chainsaw on the ground. Early models powered snowmobiles and jet skis, but later versions are FAA-approved for aircraft. The aircraft can be picked up on radar, but most search radar systems filter out low-speed targets so that they don't pick out birds or objects that don't pose threats. The Predator can fly at around 70 mph, slow enough to hide from such radars.

In the video, a wisp of cloud drifts past the camera's lens, and roads, haystacks, and villages slide by below. It looks like rural Vermont except for the busted-up houses.



The Pentagon started test flying the Predator in the fall of 1994. Almost immediately after it first saw action the following summer over Bosnia, one was shot down by anti-aircraft artillery. But it began its deployment without the radar that enables it to gather images through the clouds that help hide it. The unlucky aircraft had descended to 4,000 feet to get beneath a cloud layer and had lingered in a valley for about an hour at the behest of commanders in Naples, Italy. Its loss was virtually inevitable. Another Predator crashed a few days later because its engine quit.

Although both aircraft were lost, no mom or spouse had to open the letter that reports a loved one missing. The Joint Project Office, which manages the program, simply sent replacements and flew them for another three months before the Pentagon pulled the Predator from the theater, added the radar

Sensor operators Jaime Penrod, Jeff Fossum, and Heather Hunnel (left to right) occupy the high ground in reconnaissance technology—and they like it.

and a de-icing system, and sent it back to the Balkans in May 1996, this time with the newly formed 11th Reconnaissance Squadron operating it from Tazar, Hungary.

The Predator is the airplane the Pentagon wanted during Desert Storm, when Saddam Hussein was moving Scud missile launchers from place to place and Coalition aircraft couldn't find them. Although the Navy's Pioneer UAV flew reconnaissance missions in Iraq, it couldn't cover the territory that the Predator can. A high-data-rate satellite link enables its pilot to control it up to 400 miles away. Earlier UAVs simply lacked the Predator's range and altitude capabilities.

The 11th Reconnaissance Squadron and the 15th, activated in August 1997, took turns operating the Predator: watching borders, military installations, and demonstrations, as well as escorting convoys—when Pope John Paul II toured Bosnia in 1997, a Predator overflew his route. By the time NATO launched Operation Allied Force in March 1999, theater commanders had a pretty clear idea of what the UAV could do.

"Predator was a key asset in limiting collateral damage," says Major Scott Hatfield, a Predator program manager at Langley Air Force Base in Virginia. During Operation Allied Force, UAV operators would receive a list of

Of the General Atomics family, the Predator (center) alone has a satellite link to watch targets beyond the horizon. The Gnat 750 (left) snoops for the CIA, and the little Prowler is hoping for a customer.

30 to 40 targets—munitions plants, logistics centers, military barracks—that strike aircraft were scheduled to hit that day. Pilots would fly the Predator to each site to confirm its position and make sure it was clear of civilians or orbit slowly over a target to make sure it stayed clear. Other UAVs flew reconnaissance missions, but only the Predator can watch a target all day and, with its infrared sensor and radar,

all night. It has an endurance of more than 40 hours, but its longest mission in the Balkans was only half that.

One of its biggest fans during Operation Allied Force was General John Jumper, the commander of U.S. Air Forces Europe at the time and now the chief of Air Combat Command. He spoke about the Predator at a recent colloquy in Washington, D.C., held by the Air Force Association and the Eaker Foundation. "We have documented instances of Serbian special police using the very tractors that the civilians were using to go from house to house to burn and to kill," he said. Distinguishing between Serbs and civilians takes lots of loiter time, which the Predator has plenty of. "The UAV, especially the Predator, came into its own," Jumper told the gathering.

UAVs performed bomb damage assessment, located targets in hollows and other shadowy areas where satellites and high fliers couldn't see, and searched for mobile targets like missile launchers, which the Serbs also camouflaged. They flew what Department of Defense spokeswoman Susan Hansen calls " 'D3' missions: those that are dirty, dull, or dangerous."

Frequently, theater commanders asked Predator flight crews to depart from a flight plan after they launched. Not everyone was happy when this happened. Lower-level officers sometimes grumbled that their superiors, who were talking to political leaders, were micro-managing reconnaissance and chasing after spurious targets while mission planners were waiting for bomb-damage assessments.

Although real-time video (purists say "near real time," since there's about a half-second delay in the network) was a powerful tool, the Pentagon's daily press briefings during Operation Allied Force provided a glimpse of the frustration that must have been felt by people who were watching—live—a bully in action but couldn't always do much to stop him. At one briefing Lieutenant General Charles F. "Chuck" Wald, at the time Joint Staff Vice Director for Strategic Plans and Policy, was showing a Predator video (UAVs

Some pilots taxi using the infrared camera, with its 40-degree field of view. Controllers in the Tuzla tower talk to pilots via a voice link on the UAVs.

supplied many of the videos used in briefings) in which a tank drives over a civilian car and crushes it. A house is afire across the street, but there is no apparent fighting going on in the area. Wald, angered by the images, told the assembled media, "I'm not sure how most people would interpret this, but this is about as unprofessional as anything I've ever seen a military force do.... If I was in that military I'd probably—definitely—quit."

Imagery delivered by the Predator could have an unexpectedly strong influence on target selection. When an act of savagery is seen in real time, the impulse to strike back is nearly overwhelming. After seeing the video, reporters asked whether the tank had been taken out. Wald said that a tank in the area had been destroyed, but he couldn't be sure it was the same one. He'd been expecting the question.

The process for getting the location of a target from the Predator to a strike aircraft is not as efficient as it could be, as the Air Force has recognized in studies of its own performance during Allied Force. Officers in the Vicenza, Italy operations center read from the video the latitude and longitude of the location where the Predator was looking. They then radioed an airborne warning and control aircraft, which passed the coordinates on to strike aircraft. In certain instances the commander skipped the intermediary and talked directly to the strike aircraft. The whole process, from spotting to striking, took about 10 minutes, says Wald. But the time was dependent on whether strike aircraft were available.

The plan for the future is to have imagery from UAVs, satellites, and other reconnaissance systems all stitched together to create what Air Force planners dreamily call "a seamless intelligence picture" beamed simultaneously to command center, command and control aircraft, and ground attack aircraft. Officers in the Air Force Aerospace Command, Control, Intelligence, Surveillance and Reconnaissance Center at Langley Air Force Base in Virginia, believe they'll see such a seamless picture within a few years.

The Predator is a funny-looking little airplane, only 27 feet long with what looks like an oversize head but in reality is a compartment for the Ku-band satellite dish, which receives instructions from a pilot and sends imagery back. It has a glider's high-aspect-ratio wings. Big, slab-like tailplanes splayed downward complete the look of a hydrocephalic insect, especially when its spindly landing gear lowers for approach.

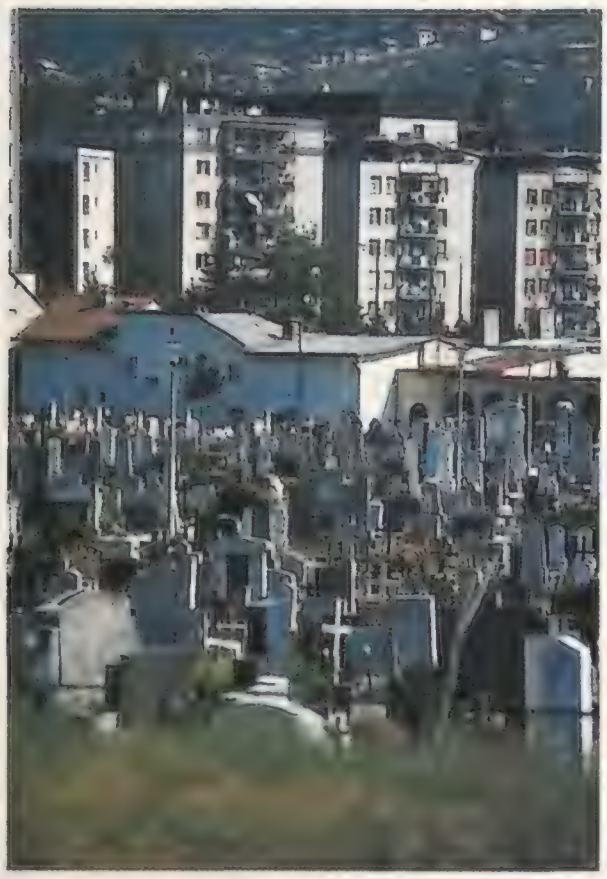
"This is the hardest thing I've ever had to fly," says Captain Craig Babbitt, a 29-year-old pilot who had been flying C-130s before signing up for a two-year tour with the Predator. "You're looking at numbers. [Even when flying on instruments] in an airplane, you have all your senses. Only one person has said he's done something harder, and that's a carrier landing."

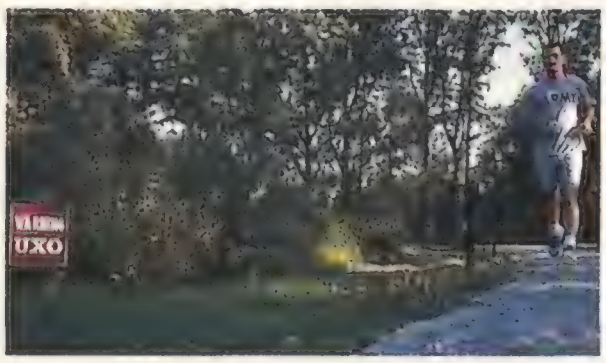
The pilot in the ground control station flies the Predator as he would a single-seat aircraft—with a stick in his right hand and throttle in his left—only instead of looking through a windshield, he's watching the 30-degree field of

GA-ASI

GA-ASI

Clockwise from lower left: Pilot and sensor operator sit side by side in a ground station. Their commands to sensors and control surfaces are received by a C-band antenna in a pod beneath the fuselage; images are returned by the same link. Two video captures show the difference in resolution between the 160-mm and 955-mm lenses of the electro-optical camera. Once the Predator is beyond the range of the C-band link, signals travel by cable to a satellite dish for transmission via a communications satellite.





Top, from left: Tom Reagan, Bayne Meeks, 15th commander Bob Ricci, Eric Palmer, and Craig Babbitt—for its pilots, Predator duty is not so much about the aircraft as it is about the career path. Reminders of war abound in Bosnia: unexploded ordnance near the Eagle Base jogging path, overcrowded cemeteries (left), the towering ruin of Sarajevo's newspaper, which continued to publish under fire.

view from the aircraft's nose camera. One pilot compares the sensation to "driving your car with paper towel tubes over your eyes."

The pilot and sensor operator, who sit side by side in the control station, face two 20-inch screens, one above the other. On the upper screen, a map of the target area is displayed with a symbol of the aircraft superimposed on it. The pilots must keep the Predator within a certain corridor a few miles in width. The corridor is also displayed on the map. "We're not so much flying a heading," one pilot said, "as we are keeping the aircraft within the corridor on our map display." Once the pilots level off at altitude, an autopilot holds altitude and airspeed.

On the pilot's lower screen, symbols overlying the nose camera video report the transponder code, airspeed, angle of attack, altitude, and other information, such as engine manifold pressure. Two smaller screens show what are called variable-information tables, displaying the positions of the flaps, for example, and engine temperature. The ground control station replicates the environment of an aircraft cockpit. The biggest difference between the two is that the Predator's pilot can switch off with a replacement and go outside to stretch his legs.

At first, engineers at General Atomics Aeronautical Systems, Inc., the manufacturer of the Predator, tried landing the thing remotely by watching the aircraft from the ground, as hobbyists flying radio-controlled models do. "The attrition rate was much higher when we flew the aircraft externally for takeoff and landing," says Allen Isbell, a systems engineer with GA-ASI. "We found that involves a different skill set, and it was much more difficult to train someone to do that." With other UAV systems, a pilot stands outside during takeoff, flying the aircraft by remote control, then hands off to a pilot inside a control station, who monitors the systems during the cruise portion of the mission, then hands back to the pilot outside for landing. According to Isbell, there has sometimes been confusion over which pilot is actually in control. "So we migrated toward flying the system as one would a manned aircraft," he says.

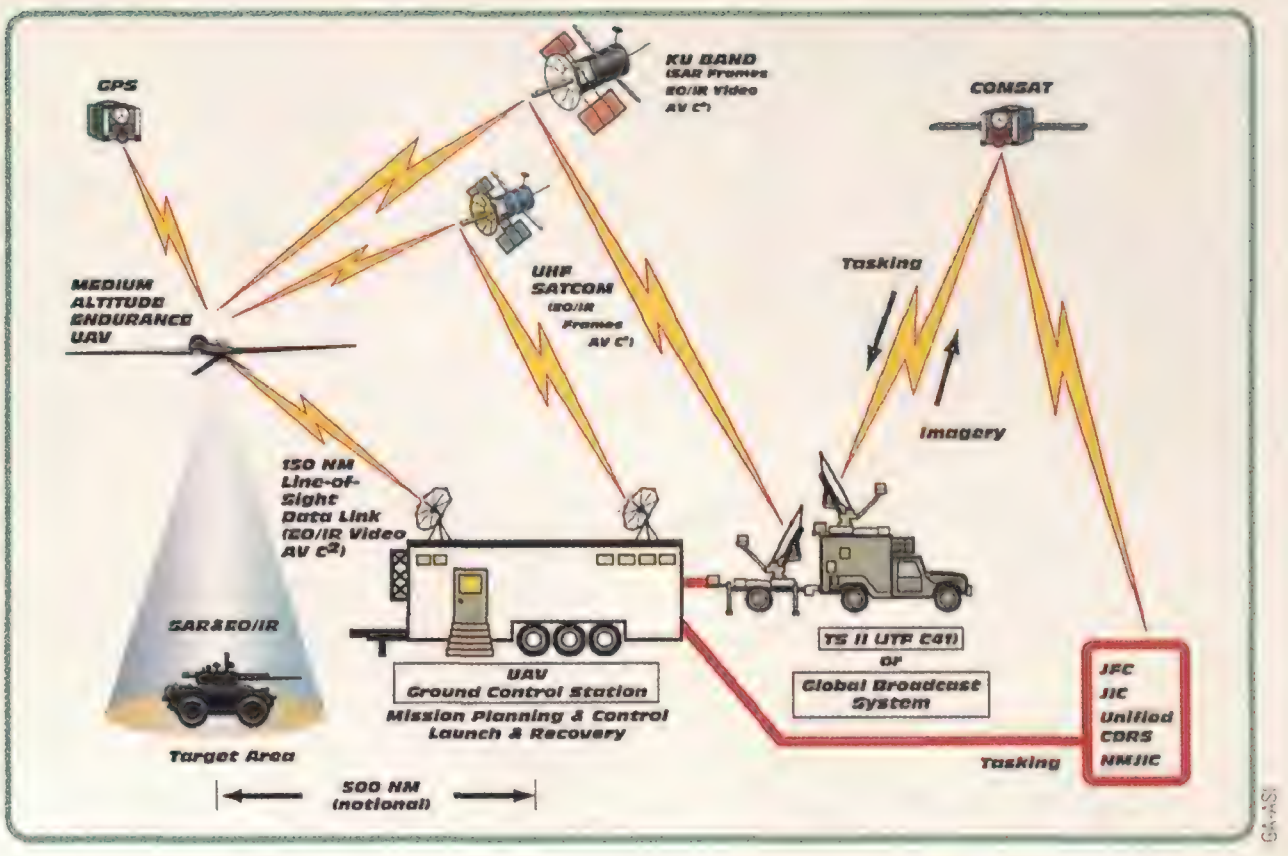
To make that possible, pilots have to receive simultaneously the nose camera's video and telemetry reporting the aircraft's condition and attitude. The high data rates and wider bandwidth necessary for that transmission became available in the mid-1980s, when microwave communications matured. The pilot's inputs on the stick and throttle are transmitted to the aircraft through a C-band radio link. Once the Predator gets beyond the range of line-of-sight communications, pilot commands are sent by cable to a satellite transmitter/receiver that passes them via Ku-band to an Intelsat 602 communications satellite for transmission to the aircraft.

Even with high data rates, however, the aircraft can't send to the pilot that seat-of-the-pants feeling he gets as he flies: no rolling tendencies, no turbulence, no sense of the sink rate, no ground rush on landing. Pilots compensate by developing visual cues to get the aircraft on the ground smoothly: When the runway fills the bottom third of the screen, for example, you raise the nose to flare.

The telemetry will sometimes tell a pilot what he can't sense by watching the video. "When you're in the standard pattern," says Craig Babbitt, "you think the nose is down, but it's still climbing. So you push the nose down harder, but that's not a very comfortable feeling. I feel very confident with it, but I still don't trust it. It's so sensitive; five knots [of wind] is a big deal for this airplane."

There are other odd sensations to get used to with a UAV. When they're sitting in cockpits, pilots frequently lean into a banking turn, and they have been trained to "check left" when turning to a left heading, for example. One pilot found himself leaning and checking left and looking at the telephone on the wall next to him. He's gotten himself out of the habit but says: "I hope that when I get back to the cockpit, I'll pick that up again."

There's a lot of buzz around the Predator these days, partly because of the star status it enjoyed after Operation Allied Force, and almost every member of the two reconnaissance squadrons formed to operate it—the 11th, formed in 1996, and the 15th, reactivated a year later—talk enthusiastically about being part of something new, something that has "future" written all over it. Still, it's hard to imagine a pilot finishing up flight training and just praying for a spot on this aircraft—or any UAV, for that matter. They are creatures only an image analyst could love.



DEPARTMENT OF DEFENSE

A diagram of the Predator's ground and satellite network shows how images, like this June 1999 video grab of a Serbian convoy, are requested and distributed.

So the Air Force entices airmen to Predator duty with the promise of a plum assignment once they do time with the "drone." They call the Predator a drone when they want to insult it, usually after they have earned an insult themselves, as in "Ugh! Bad landing! Stupid drone." It is not, strictly speaking, a drone, which is a pilotless aircraft that can sustain level flight over a programmed course. A UAV is smarter; it can fly a programmed course and react to commands transmitted to it from a pilot on the ground. If the communications link with a Predator is lost, it flies a certain course for a period of time until the link can be re-established. When its time is up, it heads toward an uninhabited area to crash.

Currently 38 pilots fly the Predator, and the Air Force will reward them all in some way. When former B-52 pilot Captain Tom Reagan leaves the 15th, for example, he will get his dream job: flying the A-10 tank killer. KC-135 pilot Jobert Calimum is moving up to a KC-10. Captain Craig Babbitt, the C-130 pilot, will get a posting at a base closer to his family.

Some couldn't be cajoled. Pilots tapped for Predator duty can refuse the assignment and leave the Air Force, if their service commitments are shorter than the length of the assignment. Pilots are given seven days to decide.

"They lose a lot of pilots like that," says Tom Reagan. "I volunteered—but after three other pilots had seven-day opted out. We counted up in my training class, and we think 17 or 18 pilots left the Air Force."

Reagan seems genuinely excited by the UAV technology, but he also sees the need for the Air Force itself to adjust to the new system. He thinks the solution is to have a trainer—a supersonic T-38 Talon or a twin-turboprop Beech C-12—for Predator pilots to use at the Indian Springs Air Force Auxiliary Field, part of Nellis Air Force Base, Nevada, home of the 11th and 15th. "Our skills deteriorate while we're here," says Reagan. "We will have been out of an aircraft for two, two and a half years. And we don't accumulate flying gates [hours that count toward

flight pay]. If we had a trainer to maintain our proficiency, we'd have better continuity and the Air Force wouldn't have the problem."

You can't please all of the pilots all of the time, as Lieutenant Colonel David Gibbs, the 11th's commander, sees it. "Every pilot will get a bad deal assignment eventually," he says. He offers the example of ALO, or air liaison officer, a pilot attached to a ground unit. The ALO doesn't fly; he advises the unit commander on air operations.

"I've flown F-111s and B-52s," says Gibbs, "and after flying a dying weapons system and an ancient one, I like the experience of flying something new." Besides, he points out, Nellis is about 40 minutes from the Las Vegas Strip. He asks: "Would you rather be an ALO crawling around in the mud with the Army, living in a tent, or would you rather come to Vegas?"

Captain Bayne Meeks hints that had he been eligible, he might have taken the seven-day option. Meeks was flying C-130s out of Pope Air Force Base near Fayetteville, North Carolina, for three and a half years, when the Predator called. "I knew it was time for me to move on at about the three-year point, but I had no idea *that* was lurking out there," he says, glowering at the UAV perched outside its hangar at Eagle Base. "I'm passionate about flying, and this is not passionate flying.

"I need some air under my butt," he mutters, walking off. "That's been my problem for a year and a half now." Yet Meeks would replay the ball camera video of his landing, over and over, watching for cues that would help perfect his landings.

For every disgruntled pilot hanging on for two years until he can get back in the air, there are ten sensor operators lovin' life. They operate the cameras and radar, and it's the sensor operator in the role of DEMPC—Data Exploitation, Mission Planning and Communication—who gets the "tasking," or daily list of targets from the operations center, plans the missions, and literally calls the shots.

"At first it was odd giving orders to pilots," says Heather Hunnel, "but they take it really well."

The DEMPC selects the sensors that will be used to "prosecute" a target, explains Senior Airman Jeff Fossum. "We go out [to the ground control station] before the flight to plot waypoints. We choose the sensor depending on the EEI—essential element of information." Intelligence collectors may want to know, for example, if armored vehicles at a storage depot have been operated recently. The DEMPC in that case would specify the use of the infrared camera, which sees the heat generated by the tanks' engines.

How long a target is prosecuted is up to the sensor operators. Trained as image analysts, they make sure the essential element of information has been captured. "Predator is a good background for crew coordination," says Lieutenant Colonel Bob Ricci, a navigator on an E-3 Sentry airborne warning and control system (AWACS) aircraft before taking command of the 15th Reconnaissance Squadron. (As a navigator, Ricci also had to have a civilian commercial pilot's license with an instrument rating in order to qualify to fly the Predator.) The sensor operators function in some ways like co-pilots, calling out airspeed, altitude, watching temperatures and warnings. Before landing, the sensor operator turns the ball camera to confirm the gear is down. "It's like any assignment on any multi-place aircraft," says Ricci.

Airman First Class Jaime Penrod, from Lake Placid, Florida, likes her work on the Predator so much that she's thinking of seeking a job with its manufacturer once she's out of the Air Force. "I want to stay connected with this system," she says. She likes the immediacy of it—analyzing images as they're created rather than second hand, days or weeks after the action.

"I've never had anybody [in its target area] notice it's in the sky," she says. "Eventually everything will be unmanned. I bet we see it in our lifetimes."

General Jumper was recently asked in a public forum if the UAV was smarter than piloted aircraft. "No," he responded, "it is braver."

Eleven U.S. UAVs were lost to anti-aircraft fire and accidents during Operation Allied Force—21, including those flown by other NATO members—"and the pilots were last seen heading for the mess hall," as Gibbs blithely

Brian Cruickshank checks a propeller mount (left). Most required repairs are electrical, he says. The aircraft packs up like camping gear for shipping (right). Two C-17s can haul a working unit of four aircraft, a ground control station, and satellite-link equipment from a U.S. base to Bosnia.

puts it. Endurance, flexibility, keen eyesight—good qualities all, but the biggest attraction in a UAV is the "U." No pilot is placed in harm's way, and the American people have made it clear that they like it like that. Casualties are unacceptable, and UAVs permit a whole new world of decision-making.

Tom Reagan, who flew B-52s before he flew Predators, could have been describing either mission when he told me, "We're going to fly at whatever altitude is necessary to avoid threats and get the job done." But only a UAV pilot could say, as he did: "Or it may come to a point where they don't want us to avoid threats, and that's the bonus with a UAV. If there's something that is time critical and they want pictures of something now because it will save lives, then we'll fly right into a threat. And so what if they shoot us down? No one gets hurt and we may find out some invaluable information."

So why stop at reconnaissance craft? In tests at the bombing ranges near Nellis, the Predator has already fired 100-pound AGM-114 Hellfire anti-tank missiles. The tests had been delayed to give Pentagon lawyers time to review the requirements of the 1988 Intermediate-range Nuclear Forces (INF) treaty, which prohibits the deployment of unmanned weapons platforms with a range equal to the Predator's.

Regardless of whether the Predator will be among them, unmanned attack craft are on the way. This summer Boeing will begin flight tests of an unmanned combat air vehicle it is developing under a $131 million contract from the Air Force and the Pentagon's Defense Advanced Research Projects Agency. And Lockheed Martin's Skunk Works is developing a similar craft in a classified U.S. Air Force program—this one small enough to be air-launched by a mothership.

Meanwhile the 11th and 15th Reconnaissance squadrons continue to operate the Predator and learn how to use it. Members of the 15th have been deployed to Saudi Arabia to patrol southern Iraq, and both squadrons have flown in Red Flag, the combat training war games at Nellis. "We're still trying to figure out how we fit in," says the 11th's Dave Gibbs. "We've already proven ourselves," says Bob Ricci.

A Predator recently crossed the line between reconnaissance and attack by test firing some Hellfire anti-tank missiles. Treaties may limit a UAV's ability to bear arms, but unmanned combat air vehicles seem to be on the horizon.

"We've done that for five years. But how do we want to use this system? What do they want it to do?"

Like a trainer toweling off a boxer between rounds, Senior Airman Brian Cruickshank is wiping down a Predator that has just returned from a mission. He and the other maintainers in the 15th Reconnaissance Squadron say that "the robot," as some call it, is a lot easier to work on than some of the other aircraft they've kept flying. "This is almost all electrical work," says Cruickshank. "Swapping out black boxes."

When you talk to crew chiefs about their aircraft, it's not uncommon for them to lean up against it, slap its side, or run their hands along a wing. Nobody touches the Predator. Nobody has a story to tell about it. They all know what it does, how it works, that it's here to stay. But its place in air force culture is tentative; its mission not yet fully defined.

FISHING for SAINT-EX

BY JOSEPH HARRISS ■ THERE'S SOMETHING DOWN THERE.

■ AND IT MAY BE ANTOINE DE SAINT-EXUPÉRY'S P-38.

SUMMER SQUALLS SOMETIMES BLOW UP ALONG FRANCE'S MEDITERRANEAN COAST, AND THIS ONE LEFT JEAN-CLAUDE ANTOINE BIANCO, SKIPPER OF THE *HORIZON*, A 60-FOOT, BLUE-AND-WHITE TRAWLER, SOAKED. "WE'D BEEN FISHING SINCE MORNING ABOUT AN HOUR EAST OF THE PORT AND THE WEATHER HAD TURNED AWFUL," HE RECALLS OF THAT SEPTEMBER 1998 DAY. "THE WIND AND WAVES WERE TOSSING US AROUND, THE SKY WAS BLACK, AND IT WAS RAINING BUCKETS. I DIDN'T EVEN HAVE MY SLICKER ON. SO I DECIDED TO HAUL IN THE TRAWL NET AND HEAD HOME ABOUT 2 P.M."

Fifty-four years after France's beloved writer-aviator Antoine de Saint-Exupéry (opposite) disappeared in a photo-reconnaissance craft, a fishing boat in the Mediterranean discovered a bracelet with his name on it. The search was on.

Bianco, a stocky, balding 54-year-old, was in his cabin drying off from the squall when Habib Benamor, his Tunisian second mate, came in and announced that among the usual mullet, anglerfish, and squid, he had found a silver bracelet. "I put my glasses on and scratched off some of the concretion that had built up around it," Bianco remembers. "I saw the name 'Antoine.' *Hey*, I said to myself, *this guy has the same name as me.* I scratched some more and saw 'Antoine de Saint-Exupéry.' I thought, *Am I dreaming or what?*"

Bianco yelled excitedly to Habib, "This belonged to Saint-Ex!" But his mate just stared back; he'd never heard that name.

That made Habib a rare bird indeed. Few have not heard of the French writer-aviator whose mix of derring-do and literary stature has made him virtually a demigod in France. His novels *Southern Mail*, *Night Flight*, and *Wind, Sand and Stars* chronicled aviation's heroic era, when cockpits were

Inspired by the discovery of the bracelet, diver Luc Vanrell (left) found what could be parts of Saint-Ex's airplane, including an oval air intake particular to the F-5B's turbo supercharger (below, in diver's left hand).

LUC VANRELL PHOTOCEANS.COM (2)

open and pilots delivered the mail come what may, and his nonfiction *Flight to Arras* was one of the first accounts of flying combat missions in World War II. His most beloved book, of course, was *The Little Prince*, a novel about a wistful, wise young man from another planet who wonders at the strange ways of Earthlings; it has been translated into 118 languages and dialects, from Azerbaijani to Esperanto. The 100th anniversary of Saint-Ex's birth last year was greeted with new biographies, the renaming of the Lyon airport in his honor, a French postage stamp, a new American edition of *The Little Prince*—which still sells some 200,000 copies a year in the United States—and an exhibit in Paris' hallowed Pantheon crypt, called, aptly, Celebration of a Myth.

The myth began on July 31, 1944. Saint-Ex had shortly before rejoined his old squadron, the 2/33, which had been dissolved in 1940, then reactivated in 1943. The squadron was part of the American Third Photo Group, Mediterranean Allied Photo Reconnaissance Wing, under the command of Colonel Elliott Roosevelt, President Franklin Roosevelt's son. At 44, Saint-Ex was nine years over the age limit to fly the squadron's P-38 Lightnings—the photo-reconnaissance version was the F-5B—which were among the fastest fighters of the day. But Saint-Ex made deals, pulled strings, and got the slot. He was of the old school, used to flying French aircraft of the 1920s and 1930s, such as the Morane-Saulnier 317, the Simoun, the Latécoère, and the Caudron, airplanes with primitive instrumentation that pilots flew by the seat of their pants. He didn't much like the P-38, calling it "a flying torpedo that has nothing whatever to do with flying and, with all its dials and buttons, makes its pilot a sort of chief accountant." He was wrung out by missions at 30,000 feet in the Lightning's unpressurized cockpit. But he loved flying with his American comrades, whose "simple and noble courage" he admired.

On July 31, the 2/33 ops officer, Lieutenant Raymond Duriez, drove Saint-Ex to the field at the Borgo air base near Bastia, on the island of Corsica, helped him into his flightsuit, and shoehorned his bulky form into the cockpit. Ground crew pulled the chocks, and at 8:45 a.m., sortie 33S176 took off for a mapping run over the Grenoble-Chambery region, east of Lyon. Allied radar at Cap Corse, on the northern tip of Corsica, followed him into southern France. He was due back at 12:30. He was never heard from again. A myth—and a mystery—were born.

Over the years, the search for traces of Saint-Ex, mostly conducted by small groups of enthusiasts, has ranged from the Alps to the Rhone Valley, the French coast around Nice-Monaco, and even Italy. One of the most determined hunts was undertaken in 1992, when Louis Roederer, a French champagne company, launched a costly two-year, publicity-grabbing expedition, engaging IFREMER, the government-supported French ocean research unit that helped

The landing gear of early P-38s had cylindrical fulcrums, while later P-38s and the F-5B variants had rectilinear ones (highlighted part of diagram). The fulcrum Vanrell discovered was rectilinear.

LEFT: LUC VANRELL/PHOTOCEANS.COM; RIGHT: JOHN MACNEILL

find the *Titanic*, to use its search equipment to scour the Mediterranean floor in the area between Corsica and the French Riviera, where Saint-Ex was presumed to have crashed. But the search came up empty.

Amateur divers have looked too. In November 1996, Marcel Camilleri, owner of a diving school on the southern coast, and friend Alain Costanzo found a P-38 wreck lying on its back in 130 feet of water in La Ciotat Bay, near Marseille. Hoping that it was Saint-Ex's Lightning, they brushed the sand off it, tamed a toothy, seven-foot conger eel domiciled in its cockpit, and set about trying to identify it.

A friend of Camilleri's went online and found Jack Curtis, who in World War II had flown 67 missions in P-38s with the Ninth Air Force, giving close support for Patton's Third Army. Now 80 and living in Rogers, Arkansas, Curtis, who maintains an active interest in P-38s, checked his e-mail one morning and saw a message addressed to him from France: "Hello! I'm scuba diver. I have found in Medditerrannée in France a P38 Lightning. I want know how to find the serial number and model."

Curtis advised looking for a small embossed plate on the instrument panel, between the artificial horizon and the gyro-compass. When the friend got the number and relayed it, Curtis checked his copies of the Air Force's Missing Air Crew Reports, phoned the U.S. Air Force's archives at Maxwell Air Force Base in Alabama, and came up with the disappointing answer: The plane was not Saint Ex's. Downed on January 27, 1944, it had been flown by Lieutenant Harry Greenup of the 14th Fighter Group, 15th Air Force.

Saint-Ex hunters are not easily discouraged. Philippe Castellano, a 42-year-old hospital technician from Cannes, probably knows more about World War II air combat over the south of France than almost anyone else in the world. He spent 15 years compiling a list of all 38 U.S. Army Air Force airplanes downed in the region, and has visited U.S. Air Force records centers at Maxwell and at Wright-Patterson Air Force Base in Dayton, Ohio. At the latter, he acquired a copy of what he calls "the Bible": the official 1,500-page record of every American aircraft lost, everywhere in the world, day by day, during World War II.

"I started looking for Saint-Ex in 1994," he says. "A fisherman told me about a wreck he had trawled across in La Ciotat Bay. I'd been diving around here for 20 years, but that was the first time I actually looked for a wreck. After three years, I found a P-38 in 95 feet of water—a mass of wings, booms, tail fins, wheels, and cables, all mixed up. For a while I was sure I'd found Saint-Ex's plane." To help with the identification, he called on Pierre Becker, a fellow airplane hunter and the head of Géocéan Solmarine, a French underwater engineering firm. The two found the contract number on one of the wreck's tail booms, and when they looked it up, they learned that the aircraft was a "J" fighter, not an F-5B. It had been flown by Lieutenant James Riley, who had been shot down on the same day as Harry Greenup, his wingman. Escorting a bombing raid by the 15th Air Force, they had been jumped by German Me 109s and Fw 190s.

Then came the 1998 discovery of the bracelet. Jean-Claude Bianco took the bracelet to Henri-Germain Delauze, who has been France's Mr. Underwater Research and Engineering for 30 years. Delauze is the founder of Marseille-based Comex, one of the world's leading deep-water search-and-exploration firms. He has no doubts that the bracelet is the real thing. "I've brought up enough silver pieces of eight from sunken sailing ships to know how saltwater corrodes silver," he says. "That bracelet is authentic."

Spending $200,000 of his own money, Delauze immediately launched a three-week secret search of the area with his sophisticated research ship, *Minibex*, using side-scanning sonar, a mini-sub, and a remote-controlled robot explorer. "My idea was to find the wreckage quickly, then announce that we had found both the bracelet and the plane," he says. "I told Jean-Claude, 'Then we'll go and have some champagne with President Chirac.' But all I found was a German Junkers 88 bomber."

Trans-Mediterranean flights were common during the war. Some were decoys (dashed lines), made by Allies to lure enemy aircraft astray. The area became littered with the wrecks of downed aircraft; no. 1, 2, and 3 are U.S. craft that went down flying between Bastia and Chambéry. The yellow sunburst is the site of what may be Saint-Ex's aircraft.

JOHN McNELL; SOURCE LE FIGARO

367TH FIGHTER GROUP ARCHIVES

Jack Curtis flew 67 P-38 missions during the war. Today, his avid interest in all things Lightning has made him a revered source of information for those on the Saint-Ex trail.

During Delauze's search, word of Bianco's find leaked out. The Office of Maritime Affairs in Marseille, acting under a law covering archaeological sites of historical interest, ordered Delauze to cease his search and told Bianco to turn over the bracelet. Because Saint-Ex had been an air force officer, the bracelet first went to the French air force, which tossed the hot potato to France's aerospace museum, the Musée de l'Air et de l'Espace at Le Bourget airport. The museum, in turn, tossed it to the Louvre museum's Center for Research and Restoration, which normally authenticates and restores art for the nation's museums. It did a quick exam under a microscope and reported that it could not say one way or the other whether the bracelet was in fact authentic.

The bracelet is now in the hands of the descendants. They have had it analyzed two more times, but they are keeping the results secret. Family representative Frédéric d'Agay, a nephew of Saint-Ex, says: "This whole affair of the bracelet has been surrounded by mystery, and we would like to clear it up. Saint-Exupéry was not known to have one [a bracelet like the one found], so we wonder what's going on." (In *Saint-Exupéry: A Biography*, author Stacy Schiff reports that the aviator did own a gold one.)

Some believe the bracelet might have belonged not to Saint-Ex but to his wife, Consuelo. That would account for her name being engraved in parentheses. They also say it is too small to fit the wrist of a hefty man like Antoine. Still, the distinction may prove a minor one. "I think Saint-Ex might have carried [Consuelo's bracelet] with him as a sort of keepsake, in a bag or pocket or even hanging on his instrument panel," says Castellano.

Now, with the discovery out in the open, other divers were inspired. One was Luc Vanrell, the owner of a diving equipment shop in Marseille. Son of one of France's diving pioneers in the 1940s, he had for years searched for an airplane wreck his father had mentioned. "Years went by and I was getting nowhere," he recalls. "But then Bianco found the bracelet. I noticed that the area he had trawled was right where I had spotted some aircraft debris. Since most of the planes sunk around here are German, I assumed it was a Messerschmitt, Junkers, or Heinkel. But now I began to think I was on to something."

Vanrell started spending time with aviation buffs like Castellano and putting together documentation on U.S. aircraft that flew during World War II. Knowing where the bracelet was discovered, Vanrell trawled over an area a mile long and 400 yards wide, and he dove to depths of 180 to 250 feet, where divers can stay only 15 minutes. The site is part of an area that has been trawled by fishermen for years, so the remains on the floor there are from all kinds of aircraft. Having discovered the invaluable Jack Curtis on the Internet, Vanrell turned to him for advice on identifying some of the parts he found. By last May he had located—mixed in with pieces of a Messerschmitt 109—a tail boom fragment with an oval air intake particular to the F-5B's turbo supercharger, a Lightning wheel, and a left landing gear. Significantly, the fulcrum attached to the side strut was rectilinear—a design characteristic particular to the late P-38s and the F-5B and different from the cylindrical fulcrum used on earlier Lightnings.

Vanrell sent Castellano an e-mail asking innocently whether any modifications had been made to P-38 landing gears. "I knew then that he'd found it," says Castellano with a grin. "I told him straight, 'If you've found a P-38 landing gear with a rectangular fulcrum, it can only be Saint-Ex's plane." Only four P-38 photo-reconnaissance craft had been downed in the Mediterranean, and the other three have been found. "All we need to locate is the serial number, 42-68223, and I'm sure we will," says Castellano's fellow searcher, Pierre Becker.

Not if the family has anything to say about it. "That plane is a sepulchre that must be respected," says d'Agay. "It's such a beautiful myth, disappearing over the ocean the way the Little Prince disappeared from the earth. Those divers are just trying to make money from selling photos."

In discussing the family's position, one French official, who asked not to be identified, wonders: "Are they acting solely in the interest of his memory, or for more financial reasons?" The descendants hold rights to royalties from all of Saint-Ex's books, and also sell Little Prince products ranging from pens and watches to stuffed animals and cosmetics. If the mystery of Saint-Ex's fate is solved, would product revenues be affected? "That's the stupidest idea in the world," responds d'Agay. "I don't need to protect revenues from

a book that's sold 50 million copies."

Apparently, the family has the ear of the authorities. According to Philippe Grenier de Monner, assistant director for archaeology at the Ministry of Culture: "The defense ministry is against [a salvage attempt], partly because the descendants of Saint-Exupéry are." The defense ministry itself will only say: "This is considered to be a private affair."

Almost no other government office will allow its spokepeople to speak on the record. And this being France, there are lots of offices involved. Locally there are the Maritime Affairs Office and the Department of Subaquatic and Underwater Archaeological Research; in Toulon there is the Maritime Prefecture. The final authorities are the ministries of culture and defense in Paris. One official at Underwater Research says, "I can't tell you what the government's position is on this because it hasn't declared one yet, and I think it'll be quite a while before it does. It's all very Latin."

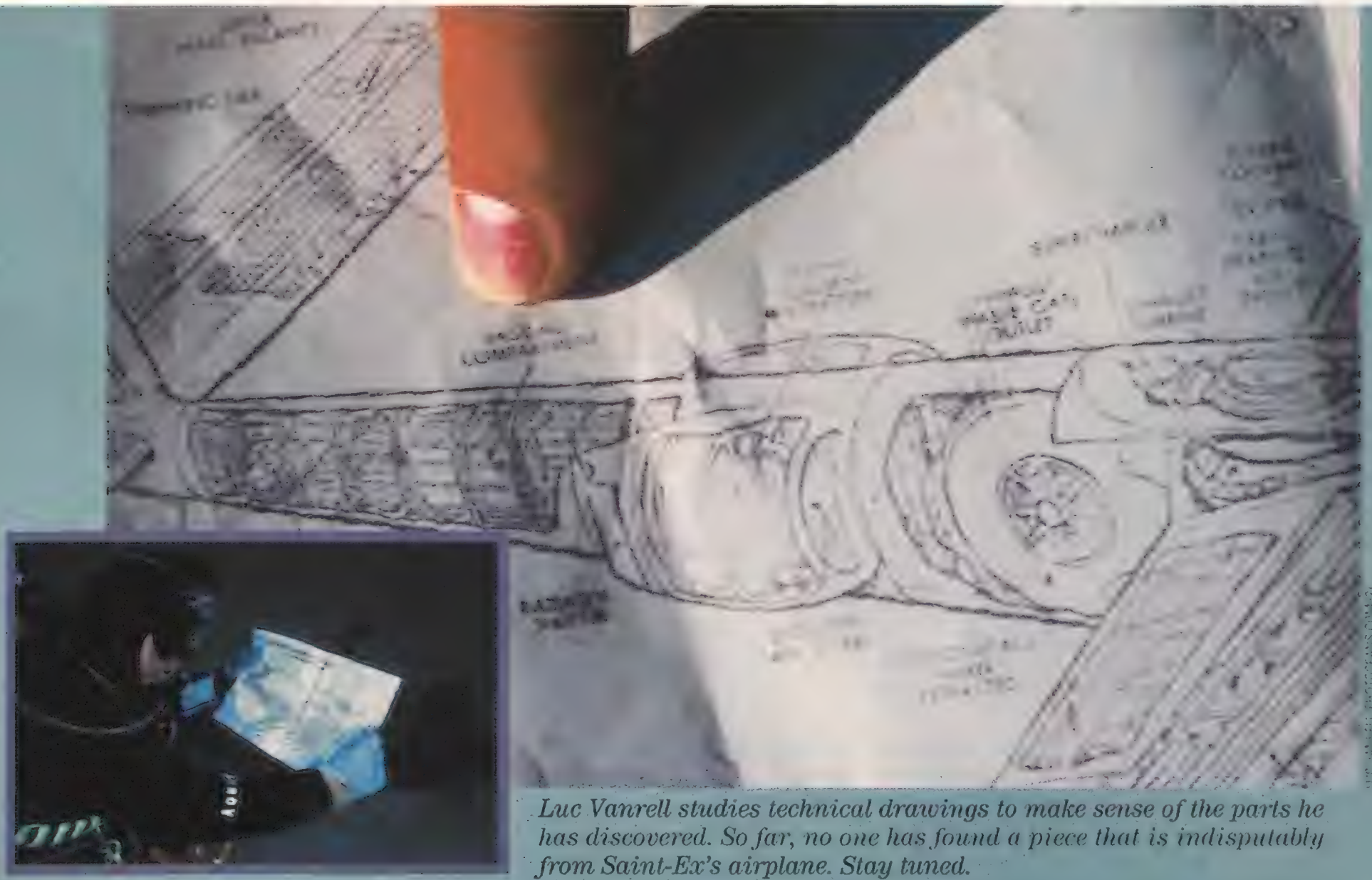
On May 12, 2000, Vanrell officially declared his find to the Maritime Affairs Office in Marseille, which duly forwarded the report to the local Department of Subaquatic and Underwater Archaeological Research, a branch of the Ministry of Culture. Initially, the culture ministry planned to hire Vanrell, Delauze, and others to undertake a 10-day study of the site: mapping, photographing, filming, and raising parts for examination. "We were ready to go," recounts Delauze, "but suddenly the culture ministry said they'd had a call from the prime minister's office: 'Don't touch it.' "

This stamp was issued by the French last year on the 100th anniversary of Saint-Ex's birth. His disappearance gave him iconic status.

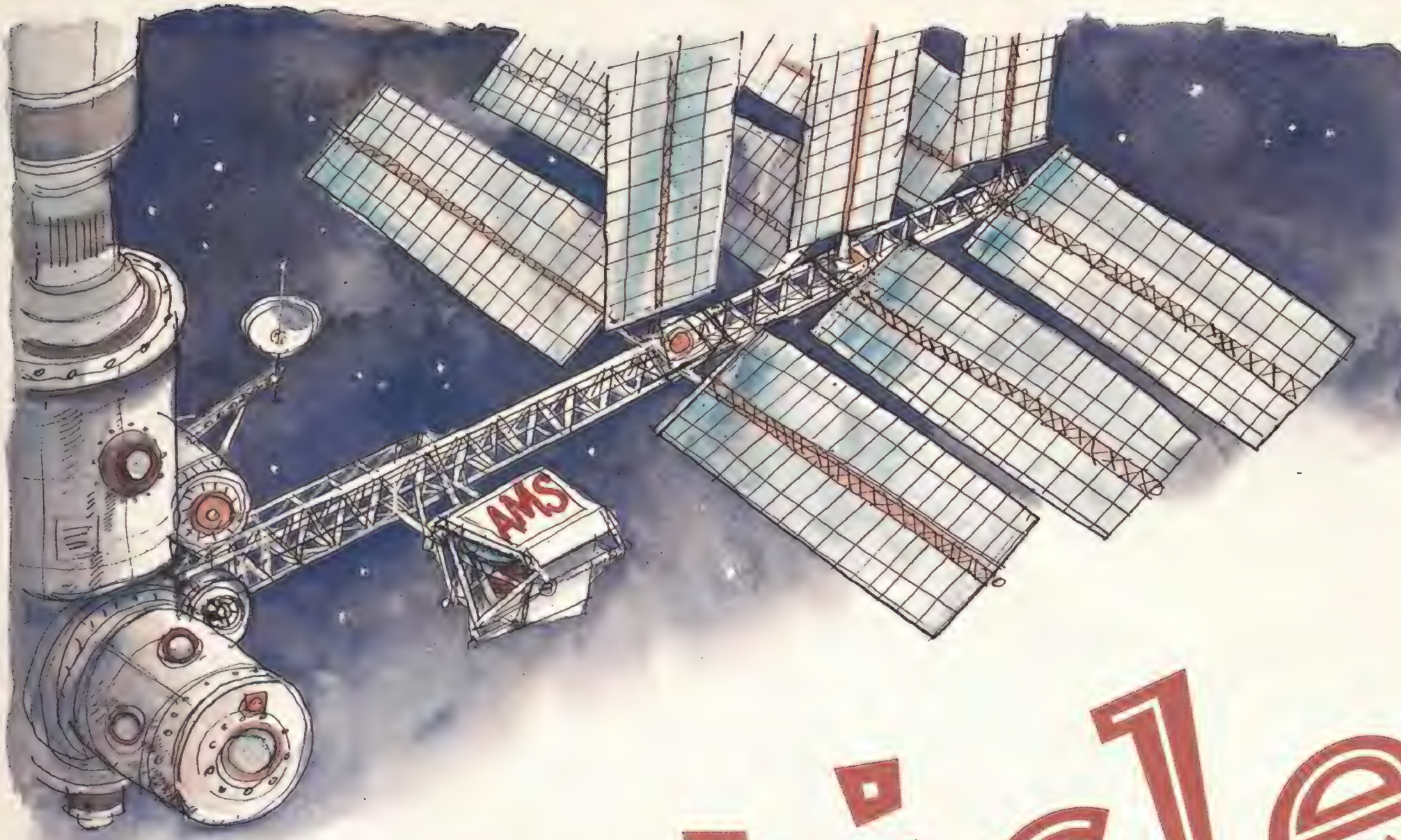
"For us at the culture ministry, this is not a scientific priority, and it would be very expensive," Grenier de Monner says today. "And if we did excavate it, that could lead to requests by families who lost members during the war for us to do costly excavation of other wrecks. We don't want to encourage that."

Philippe Castellano is optimistic about breaking through the bureaucratic inertia. "This has now gone too far for anybody to stop it," he says. But the ministry of culture's Grenier de Monner disagrees: "Unless there's a surprising, high-level political decision," he says, "I don't believe this excavation is going to happen."

The simple quest for historical truth has produced a very complex French *affaire*. At stake is the future of the myth of Antoine de Saint-Exupéry—and the possibility of ever learning what really happened to him.



Luc Vanrell studies technical drawings to make sense of the parts he has discovered. So far, no one has found a piece that is indisputably from Saint-Ex's airplane. Stay tuned.



Particle M

Sam Ting is on a mission: Find the other half of the universe. By Andrew Lawler

Illustrations by Richard Thompson

High above the Florida dunes, a group of excited visitors clambers over the metal grates at the top of the space shuttle launch pad. As a cool winter wind blows and a pale, nearly full moon rises over the Atlantic, they chatter in French, German, Chinese, Italian, and Korean, snapping pictures with disposable cameras. No ordinary tourists, this group of VIP physicists is here on a working trip. Their usual haunts are vast underground tunnels near Geneva, Switzerland, that house gigantic particle-smashing accelerators central to their research. But an unusual experiment slated to be launched in two years from this spot at NASA's Kennedy Space Center has brought the scientists out of their holes for a look at the stars.

The Pied Piper luring them to this upper world is Sam Ting of the Massachusetts Institute of Technology, a Nobel prize winner famous for thumbing his nose at scientific orthodoxy. The trim and dapper 65-year-old physicist has set his sights on finding evidence of a long-theorized anti-matter universe—a chase that many scientists, including some on his own research team, say is extremely long on odds. Undaunted, Ting has deftly used a combination of political savvy, his own reputation, and managerial muscle to persuade 16 governments and

hundreds of physicists and engineers around the world to join him in a multimillion dollar quest to find exotic particles that may not even exist.

Ting's plan is to attach a massive magnet called the Alpha Magnetic Spectrometer (AMS) to the outside of the International Space Station, where he hopes it will attract passing bits of anti-matter—particles with an electrical charge opposite that of ordinary matter. If such anti-atoms exist and can be captured, the finding would solve one of the great mysteries of modern cosmology—namely, what happened to all the anti-matter that should have been created in equal parts with matter at the time of the Big Bang.

Never mind that in the past decade, dozens of balloon flights have tried to find primordial anti-atoms and failed. "No risk, no reward" is the unofficial rationale behind the AMS. "This program clearly has a very low probability of finding primordial anti-matter," says Hans Hofer, a longtime colleague of Ting's at the Swiss Federal Institute of Technology in Zurich. "But if you find it, you'll be famous."

And fame is as coveted in the research world as it is in Hollywood. Ting is certainly a research superstar, but he has also earned a reputation for abrasive toughness that rubs many the wrong way. No surprise, then, that astrophysicists resent his sudden appearance on their turf—the heavens—and the way he used his connections to win the support of NASA Administrator Dan Goldin. Many high-energy physicists see the space station experiment as being on the fringe of legitimate research, while to others, the AMS is nothing more than a big gamble by a big ego to grab headlines. Even his own colleagues joke that the program's acronym is a deliberate scramble of Ting's first name.

But Ting says his venture ultimately is not about turf or headlines but about the excitement of exploration. The challenge of being the first to discover primordial anti-matter forged in distant anti-galaxies is simply too tempting to pass up. "And if you don't do it," he says, "someone will do it better."

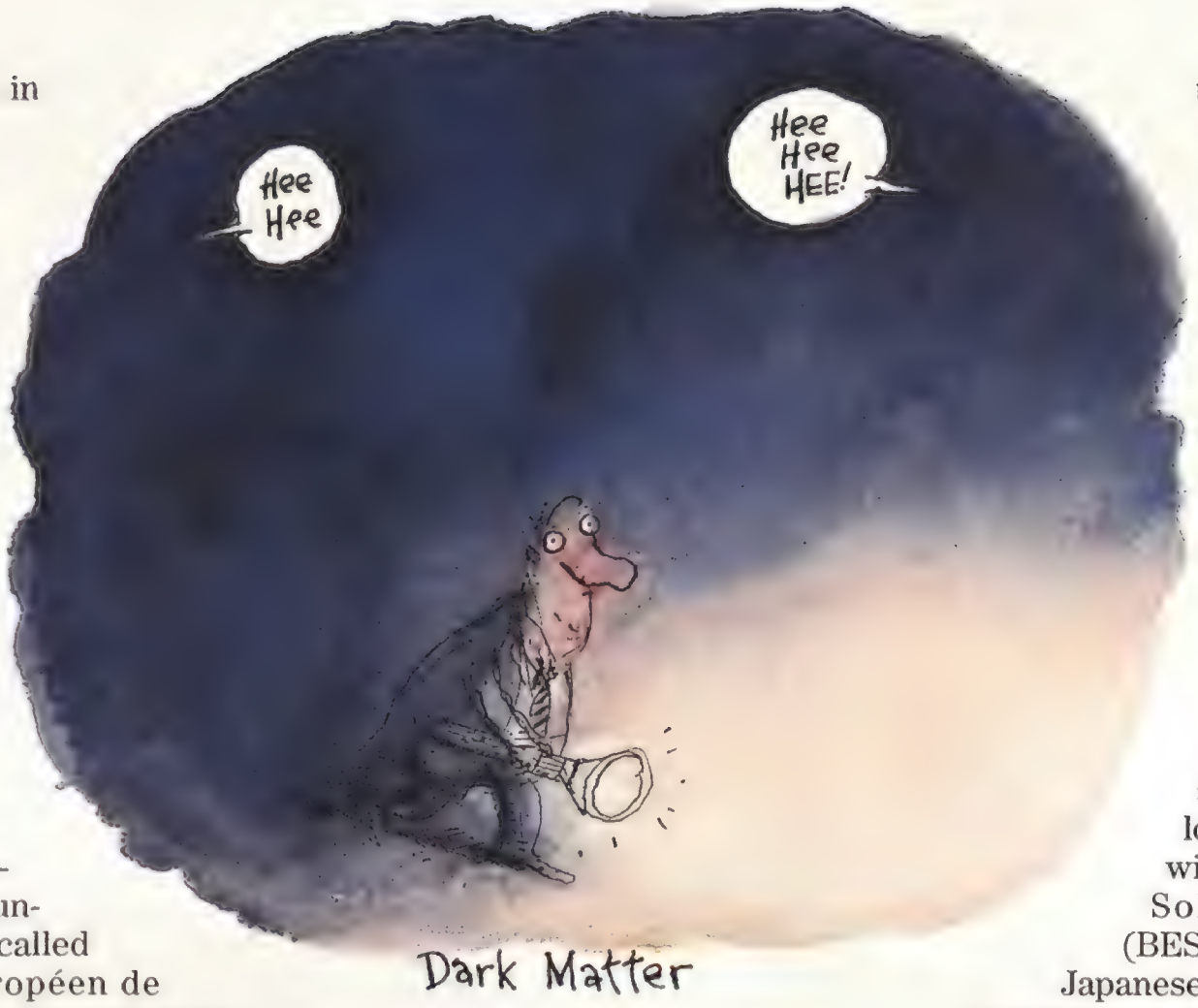
As early as 1898, British physicist Arthur Schuster suggested the existence of "anti-atoms" that mirror the building blocks of ordinary matter. In the early 1930s, his countryman Paul Dirac described the behavior of electrons in equations that for the first time married Einstein's relativity theory with the new Alice in Wonderland concepts of quantum mechanics. One curious byproduct of Dirac's equations: They required, along with ordinary, negatively charged electrons, the existence of anti-electrons with a positive charge—anti-matter.

Proof came almost immediately. In 1932, physicist Carl Anderson of the California Institute of Technology discovered one of these "positrons" in a laboratory cloud chamber while studying the tracks of cosmic rays—very-high-energy particles streaming in from space. Half a century later, German physicist Werner Heisenberg would call Anderson's discovery, which had won him a Nobel prize, "perhaps the biggest jump of all the

big jumps in physics in our century."

By the mid-1950s, physicists using large particle colliders had succeeded in manufacturing an anti-proton by smashing together two ordinary protons at fantastic speeds. Since then, giant accelerators have sprung up—or, more accurately, sprung down—in Europe, the United States, Russia, and China. In 1995, researchers at a vast underground complex called CERN (Centre Européen de Recherche Nucléaire), located on the border of Switzerland and France, opened a new door into the anti-world. By colliding anti-protons and xenon atoms, they produced anti-atoms of the most basic element, hydrogen—one anti-proton and one positron. The anti-atoms lasted only 0.00000004 second before being annihilated by ordinary matter, but they left signals that confirmed their existence.

Scientists have also seen anti-hydrogen in nature. Mimicking what happens in accelerators, cosmic ray particles crashing into particles in the atmosphere produce a secondary shower of anti-protons and positrons. But high-altitude balloons have yet to detect anti-atoms of heavier elements—which could only be forged inside distant anti-matter stars by nuclear fusion, just as ordinary carbon, iron, and other elements are created in the furnaces of ordinary stars. In other words, we see no evidence of anti-stars and anti-galaxies wheeling in the sky. And that presents astrophysicists, who like symmetry, with an embarrassing question: If the birth of the universe created matter and anti-matter in equal parts, as



Dirac's equations demand, where's the other half?

The best explanation offered to date is that our universe is all that remains of the mutual annihilation of matter and anti-matter that took place shortly after the Big Bang. The two materials duked it out until only a small amount of matter—what we today call the universe—was left standing. That means matter was granted some slight advantage. Scientists call this puzzlement the charge parity violation—"CP violation" for short.

High-energy physicists are busy investigating the theory in accelerators, while astrophysicists look for signs of anti-matter stars and galaxies. Until one or the other succeeds, says Steve Ahlen, a Boston University physicist involved in the early stages of the AMS project, the jury is still out: "No one really can demonstrate how the universe could have no anti-matter," he says.

Enter an experimentalist like Ting, who has little patience with theorizing. "If you listen to the theorists, you would do nothing," he says. So when the anti-matter question caught his attention in 1994, Ting ignored the warnings of colleagues and starting working on ideas that could turn up primordial anti-matter.

Though his is the most ambitious, it is not the first. As far back as the 1970s, fellow Nobelist Luis Alvarez was on the trail. More recently, two high-altitude instruments—the Balloon-borne Experiment with a Superconducting Solenoidal magnet (BESS), run by NASA and Japanese researchers, and the High-Energy Anti-matter Telescope (HEAT), sponsored by a consortium of universities, have counted about 1,000 anti-protons to date, the results of cosmic ray collisions in the atmosphere. But still no sign of heavier anti-atoms forged inside anti-stars. The CP theorists doubt they are there to be discovered, and even some experimentalists have grave reservations about finding them.

One reason is distance. No significant amount of anti-matter is believed to exist in our own supercluster of galaxies, or within about 30 million light-years of Earth. If it did, we would see enormous flashes of gamma rays from the mutual destruction of matter and anti-matter—and we don't. Any anti-atoms created in anti-galaxies must have originated near the edge of the visible universe. In theory, those anti-particles could have crossed that vast distance to reach Earth, but most would have been trapped by the magnetic fields surrounding stars and galaxies along the way. "Even if anti-stars and anti-galaxies exist, they are so far away it would be quite hard for particles to come close enough for observation," laments Dietrich Müller, a University

THE BEST EXPLANATION OFFERED TO DATE IS THAT OUR UNIVERSE IS ALL THAT REMAINS OF THE MUTUAL ANNIH

of Chicago physicist and spokesperson for the HEAT project.

Yet Ting has made a career of proving the common wisdom wrong. His proposal in the early 1970s to search for a new kind of particle that decays into pairs of electrons and positrons was turned down by several accelerator committees; he was finally given a shot at the Brookhaven National Laboratory on Long Island. By 1974, after 18 months of experiments, he had found what he was looking for. Nearly simultaneously, Burton Richter of Stanford found the same thing, and they shared the Nobel Prize for discovering the "J-psi" particle two years later.

Ting was only 40. It was an astonishing achievement for a Chinese immigrant who had arrived in Ann Arbor, Michigan, two decades earlier with only rudimentary English and $100 in his pocket. He quickly earned scholarships that led to a physics doctorate in 1962. "He was a young man in a hurry," recalls Lawrence Jones, who had co-chaired Ting's thesis committee and is now an emeritus professor at the University of Michigan. Ting joined the MIT faculty in 1969, and his interest in particle physics took him frequently to CERN in Geneva. There he came to lead one of the costliest basic research projects in history: the L3 Experiment, which involved nearly 500 physicists from 40 institutions and cost $200 million for equipment alone.

By 1994, the peripatetic Ting was in search of a new challenge. The collider used for his experiment was due to be shut down to make way for a larger machine, so his work at CERN to discover yet more microparticles was soon to end. The U.S. Congress and the new Clinton administration had killed the massive Superconducting Super Collider the year before. And Ting's proposal for a massive experiment using CERN's next big accelerator, the Large Hadron Collider, had been rejected.

That left few options in the traditional field of high-energy physics. So in early 1994, Ting called together a small band of colleagues. It was one of those rare moments when researchers have a chance to be wildly creative. "For a couple of months we sat around and gave any good idea a hearing—as well as a lot of bad ideas," recalls Peter Fisher, an MIT collaborator. "It was an extraordinary time, sitting around with all these great minds." Boston University's Ahlen pushed for building a massive collector deep in a Tibetan canyon to search for gamma rays from space, while others proposed spacecraft that would carry sophisticated particle detectors.

The Tibetan idea was rejected as impractical—too many dump-truck loads needed, too many problems with theft and bureaucracy. Launching a spacecraft seemed daunting too, although the Russian government had cheap rockets for sale. Ting jetted off to Moscow to discuss a deal. He also asked Roald Sagdeev, the former head of the famed IKI space science institute in Moscow and now a physicist at the University of Maryland, to listen to the group's ideas. Intrigued by the antimatter proposal, Sagdeev called NASA's Goldin, who promptly invited Ting for a visit. "It was really a summons to Washington," says Fisher. "And not many people summon Sam Ting."

The two men were well matched to make a deal. Ting wanted support for his mission, and Goldin desperately wanted scientific credibility for his space station, which was under fire from Congress and critics for being a $100 billion waste of time. Just one year before, the station had narrowly avoided cancellation. Goldin had a platform on which to hang a big magnet, and Ting was a big name.

Both men also have reputations as out-of-the-box thinkers impatient with bureaucracy. Ting wanted control over the project, and Goldin knew that the standard NASA science and engineering reviews would bog the proposal down and possibly kill it. For one thing, the AMS would have to get in line with other projects. Standards for flying NASA equipment were also stringent. "Mr. Goldin said, 'You'd better go through the Department of Energy—if you go through NASA you'll never get out,'" recalls Ting with a laugh.

So the easier route was to keep the anti-matter search a De-

partment of Energy project, with NASA providing the launch, real estate on the space station, and some operational help. That way, the AMS wouldn't compete directly with other space missions for funding. In turn, Ting promised his Department of Energy sponsors that he would get the bulk of his funding from overseas, leaving the department obligated only to pay a modest $7 million—a bargain, given the cost of most high-energy-physics experiments. For Goldin, it was a no-lose situation. "If it doesn't work, then it's a Department of Energy payload. If it does, then NASA will take all the credit," jokes MIT's Fisher.

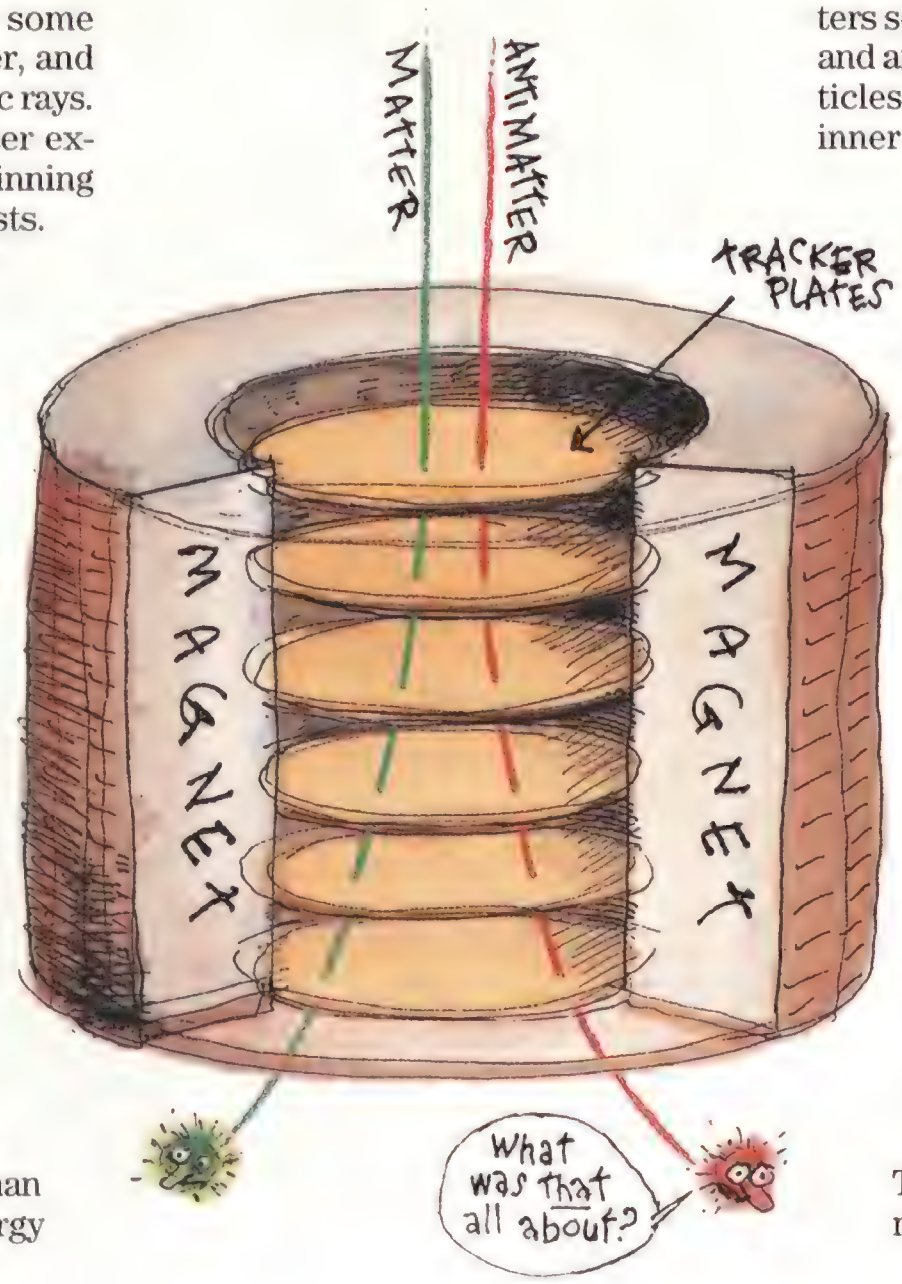
Ting and his small team closeted themselves for two months, putting together an extensive proposal for the AMS. To expand its scientific goals beyond just the search for primordial antimatter, the team made room for experiments to look for evidence of dark matter, which likely makes up some 90 percent of all ordinary matter, and to investigate the origin of cosmic rays. For Ting, these bread-and-butter experiments had the benefit of winning over more conventional scientists. "I'm personally not very interested in this," he admits.

After a series of formal reviews, the proposal won approval from independent panels of scientists. Many critics still grumble about the fast-track decision, saying it was politically motivated. AMS collaborators bristle at the claim, saying the program went through traditional peer review and is taking no money from other U.S. projects, as its funding comes mostly from European countries. The decision was, however, sobering news for the small cadre of astrophysicists conducting balloon-borne antimatter searches. Ting's project spelled the beginning of the end for those efforts, says Jonathan Ormes, who heads the high-energy astrophysics lab at NASA's Goddard Space Flight Center in Maryland. It would be nearly impossible to compete with the AMS, with its more powerful magnet and far longer life.

NASA and Ting's group also agreed to first conduct a test flight on the space shuttle. They wanted to be sure that the technology would work, that it would be safe, and that it was well tested. "I didn't understand then how hostile the space environment is," Ting admits.

AFTER THE SUCCESSFUL SHUTTLE FLIGHT, TING GOT A GREEN LIGHT TO BUILD THE SECOND-GENERATIO

Most high-energy physics experiments work perfectly well in normal temperatures and atmospheric conditions, and can be easily modified if operators need to tweak the hardware. The AMS would be strapped to trusswork 250 miles in space, would be subjected to brutal sunlight and freezing shadow, and, once launched, would offer scientists only limited access to its systems.



So with no previous spaceflight experience, Ting set out to raise a team and the money to design, build, test, and fly the first experiment. The challenge sent the physicist on a frenetic round-the-world mission to lobby colleagues and their government ministers. The speed with which he worked astonished NASA managers, who can spend 15 years or more getting their projects from concept to orbit.

The instrument Ting's team designed for the shuttle flight is a two-ton cylindrical magnet that is about three feet high and three feet in diameter at the core. The magnet creates a uniform field; a piece of matter entering the bore of the cylinder will bend one way, while oppositely charged anti-matter will bend another. Arranged like parallel shelves inside the bore hole are a series of highly sensitive detector plates that measure a particle's speed, momentum, charge, and path. A system of counters sorts electrons from anti-protons, and another counter rejects those particles that leave or enter through the inner shell of the magnet, to rule out particles bouncing off the AMS itself. Colliding particles of dark matter—the invisible stuff whose presence physicists infer from its gravitational effect on the visible universe—also should produce telltale antiprotons, positrons, and gamma rays, and the AMS includes instruments to measure the spectrum of such particles. The same instruments can help characterize incoming cosmic ray particles. All data is transmitted directly to NASA's Johnson Space Center, with no assistance from the astronauts.

Pulling all of these pieces together required help from more than a dozen countries. To produce the strong magnetic field he had in mind, Ting had to go to China, the primary source of a high-grade

neodymium-iron-boron alloy favored for making powerful magnets. His fluent Chinese helped him win a quick endorsement from the Chinese Academy of Sciences, which agreed to build the magnet. He assembled a team of Germans, Italians, Finns, and Swiss to provide the silicon tracker plates, while German and Italian teams coordinated the design and construction of the counters. Engineers and scientists from more than half a dozen countries pitched in to provide electronics, software, and ground support systems.

The 1998 shuttle mission STS-91 proved a success, save for an annoying problem with downlinking data from orbit. Although the week-long test run did not find any evidence of primordial anti-matter, it did spot anti-protons, and all the instrument's systems worked as planned. So Ting had a green light to build the second-generation instrument, which will be attached to the outside of the space station in 2003 for a three-year experiment — long enough, he hopes, for a wayward anti-particle from an anti-star to find its way to his magnet.

Like the conductor of a complex symphony, Ting manages every aspect of the project himself. His reputation as a control freak was on display at a recent meeting in a windowless room at Kennedy Space Center. Sitting front and center, he kept his speakers on a tight schedule during the brutal three-day gathering. "Avanti! Avanti!" he urged an Italian colleague who paused to answer a question. Weary physicists eager for a coffee break would make a move for the door, only to be told by a smiling Ting, "No coffee until after the next presentation!"

But Ting also knows to add levity to what often becomes a grinding nuts-and-bolts process. He bet one Italian colleague five dollars that he couldn't set up a Powerpoint presentation with his laptop. When the Italian succeeded, Ting reluctantly paid him off, but later got revenge by hiding the same laptop, making his frantic colleague search everywhere.

His team members, which include some of the most distinguished physicists in the world, submit to Ting's antics because they trust him to get the job done. "He's driven purely by science," says Roberto Battiston, a physicist at Perugia University in Italy. "Even if a technical decision means political disaster, he doesn't care."

Ting knows that simply being an autocrat, without a good argument to back up his judgments, would never work. "In an international collaboration, you cannot order people around," he says. "You can only convince people, because they do not report financially to you." Still, it's a far cry from the multi-national committees that typically run Big Science projects, with their endless meetings and consensus building. "He's not democratic at all," says physicist Cristina Vannini of the National Institute of Nuclear Physics in Pisa, Italy. "Democracy doesn't work—there must be one person who decides."

His toughest call to date, Ting recalls, was to rule out using the Chinese-built magnet for the space station flight—a major blow for Chinese researchers. Instead, the team turned to a far more powerful superconducting magnet, which will be much more expensive. Ting also regrets that Russia was unable to join the program for lack of funds.

Russia is, however, involved in another anti-matter experiment, which rivals—or complements, depending on your viewpoint—the AMS. Called PAMELA, the project is slated to put a much smaller magnet into space on a free-flying satellite next year, although it likely will be delayed. Russia is supposed to provide the launch vehicle, while a small team of mostly Italian researchers is building the device. Since it has to carry its own power source, the magnet is much smaller and has a shorter lifetime than the AMS's magnet. Ting also points out that PAMELA will only have one-thousandth the sensitivity of his experiment. But some of his collaborators say that while it lacks the sophistication of their device, the Russian instrument could provide additional evidence of anti-matter.

Ting, though, is clearly aiming to be first. He's already pondering what a third AMS mission would look like. And he seems untroubled by the skeptics. "He doesn't care," says Ahlen. "He's happiest just exploring."

If his gamble pays off, Ting may someday have big news to report to the world. In the meantime, the particle physicists on his team are looking outward to the stars, and astrophysicists are paying closer attention to their colleagues from underground. That alone may be progress for those with the difficult job of explaining why half the universe has gone missing.

First it carried a Japanese bomb 5,000 miles across the Pacific.

Then it carried Don Piccard across Minneapolis.

by Don Piccard

One Balloon Bomber (Slightly Used)

It was my first solo flight: riding a Japanese paper bag across the winter skies of the Twin Cities in 1947. But as paper bags go, this one was exceptional. In its prior service, the carefully crafted balloon had carried a Japanese bomb 5,000 miles across the Pacific—one of thousands sent to wreak havoc on the western United States.

Most failed—only 300 of the 9,300 launched were recovered in the United States, Canada, and Mexico, and only a few of those actually exploded. (The one I later used fell in a field near Flint, Michigan.) But had the other 9,000 succeeded, their incendiary bombs could have caused considerable damage to forests, crops, and whatever cities they encountered—and their "anti-personnel" bombs could have killed scores of civilians. Because the United States had no economical defense against the 30-foot hydrogen balloons—their stealth and high altitude would have made shooting them down individually virtually impossible—Project Fu-Go, as it was known in Japan, could have become one of the first effective intercontinental bombing systems.

MINNEAPOLIS DAILY TIMES

Jeannette Piccard helps her son launch his first solo flight.

In the end, though, the final act of the Japanese balloon bomber program was in my own personal adventure. I wanted to earn my Free Balloon Pilot Certificate from the Civil Aviation Agency (now the Federal Aviation Administration). It was to be the first one; other balloon pilots had FAA Airship Pilot Certificates, which carried their free-balloon pilot privileges, but none had the certificates exclusively for such flights. I had flown over 40 hours in balloons so far, and racked up eight of the two-hour flights that were needed for certification, but I still needed a two-hour solo to complete the requirements. I chose the Japanese paper balloon to make that flight.

As a member of a family with a long history in balloon experimentation, my interest in this unique balloon was almost inevitable. My father Jean and his twin brother Auguste had invented the bathyscaph, and Auguste had converted that invention to create the stratosphere balloon. Later, he and my cousin Jacques succeeded in building bathyscaphs to take them to the bottom of the sea. My parents became famous for their own stratospheric research in the 1930s, and my cousin's son, Bertrand Piccard, was one of the pilots of the Breitling Orbiter III, which in 1999 made the only free balloon voyage around the world. The gondola

now resides in the National Air and Space Museum.

I came into possession of a Fu-Go balloon while serving at the United States Naval Air Station at Lakehurst, New Jersey, an airship base and research facility to which the Navy sent some of the captured balloons for examination, and to which they sent me presumably because of the stratosphere balloon connection. (Until that point, my only ballooning experience was a single flight in a tethered research balloon with my mother. But how many of my colleagues could say *that*?) It was there, during the final days of World War II, that I acquired my 40 hours of flight time in the Navy training balloons, and where my love affair with the Japanese paper balloons was ignited: They were very well-made, very lightweight, and, most importantly, very available.

Project Fu-Go began in November 1944 and continued until the end of April 1945. The balloons were launched from three sites on the east coast of Honshu, east and northeast of Tokyo. Thirty feet in diameter, weighing 150 pounds, and having a volume of 19,000 cubic feet, the balloons were composed of panels of laminated tissue paper made from the bark of the Kozo bush. A lacquer-type chemical waterproofed the paper.

Once launched, the paper balloons floated at around 30,000 feet on the jet stream. Gas pressure relief valves and a series of 32 paper sandbags, tied up like Italian cheese loaves, helped maintain the proper altitude and flight duration needed to reach the United States. The bags were released by small explosive charges—fireworks, actually—set off by long delay fuses and switches triggered by atmospheric changes. Once over the United States, the final charges would release two 12-kilogram incendiary bombs and a single 15-kilogram anti-personnel bomb.

The effort ended when the cheap pyrotechnic controls used on the balloons failed. That enabled the United States to retrieve some of the ones that landed throughout the western United States and hadn't self-destructed. Most of the balloons fell short, dropping into the Pacific. Of those that did reach the States, only one resulted in tragedy—a mother and five children were killed when they found and accidentally set off a downed bomb while on an outing. (They were the only casualties that resulted from direct enemy action in the continental United States during the war.) Thus, little was accomplished by the Japanese balloons.

I was the sailor assigned to haul the leftover balloons down to the Lakehurst dump after the Navy had finished testing them, so I was able to get a "Property Pass" to salvage one and take it home as a souvenir of "captured enemy equipment." I didn't know how I would ever be able to get it airborne, but I had dreams. There were no civilian balloonists active anywhere in the States then. But, after the war, I became a student in aeronautical engineering at the University of Minnesota—then the nation's center of balloon research—on the GI Bill. Both Ralph Upson, a Gordon Bennett Balloon Race champion, and Jean Piccard, my father, were on the aeronautical engineering department faculty.

When I went to Minnesota, I also joined the Army Air Forces Reserve Officers Training Corps. The ROTC didn't have a ballooning program, but my supervisor, Colonel Walter Gerzin, thought it would be an excellent extra-curricular activity because of the ROTC's

Panels of laminated tissue paper made up the Fu-Go, while a remnant from a research balloon flown by the author's mother served as a ground cloth.

MINNEAPOLIS DAILY TIMES

historical connection to ballooning—the first officer to be qualified by Orville Wright in airplanes was also the first Gordon Bennett winner, Frank P. Lahm. With the upcoming 1947 creation of the U.S. Air Force, Gerzin saw great potential for publicity in a public ascension in a Fu-Go balloon. We didn't have an Advanced Corps Air Force R.O.T.C. uniform, but we cobbled one up from my father's World War II Eisenhower jacket and a variety of insignia. It may have been the first-ever U.S. Air Force uniform.

After that, many others chipped in to get the project aloft. Mike Schoenfield, who ran the aero lab, taught me how to weld and rivet sheets of surplus aluminum to make a small car. Dana Eckenbeck donated some sophisticated AcroNuts to solve an assembly problem with the spun aluminum gas valve. The Fuller Company figured out how to make a glue that would hold the Japanese mulberry paper—I had to fix the damages sustained from the first landing, in Flint, Michigan. But most important, the *Minneapolis Daily Times*' promotion department agreed to buy sand ballast and a two-thirds filling of hydrogen. (If I took off two-thirds full, I would float automatically at 12,000 feet. From that original altitude, the flight would take long enough to qualify me for my pilot's certificate.) One has to drop sand to arrest any undesired descent. That means you drop sand when you are screaming down, and it flies right back in your face. The sand had to be the finest kiln-dried, so that I could drop it anywhere without causing damage or injury. Clumps of frozen sand would do more damage than the poor thing's bombs had done on its first voyage from Honshu to Michigan. At Lakehurst, we had used beach sand for ballooning. (It was surprising how often we had to go to the Jersey coast on sunny days to replenish our supply!)

ST PAUL PIONEER PRESS / MINNESOTA HISTORICAL SOCIETY

An ecstatic young pilot has his angel food cake and eats it too.

While talking to the newspaper's director of promotions, I suggested that he subscribe to a clipping service so that he could justify the costs to his boss by showing how much the press would publicize the newspaper. That was a dumb thing to do, as the bill for the clipping service ended up far greater than the one for the hydrogen and the kiln-dried sand ballast. It became clear that public interest in the future of aeronautics in the brave, new post-War world was much higher than I anticipated—or else it was a very slow news day—and I think every paper in the country mentioned the flight, from the *New York Times*, in a front page box, to the most remote country weekly. All of this to the tune of 50 cents per clip.

Upson took me aside and reassured me that the balloon was safe. He had done the calculations, and he figured that the Japanese paper had a 50-to-1 safety factor.

The *Times* promotion, begun weeks in advance of the scheduled February launch, was a well-coordinated build-up. The background series was a marvelous Ballooning 101 course to introduce aerostatics to the public. Weekly and then daily articles about the "*Daily Times* Balloon Ascension" told tales of balloon history, romance, and science.

Colonel Gerzin called for volunteers from the corps to serve as my ground crew, and we had a great turnout. Both of my brothers and my parents joined in. I was lucky to have my brother Paul, because we found one hole I had missed that needed some last minute taping, and, at six-foot-six, he was just tall enough to get the job done.

Then came the big day—but we didn't even bother to show up. That Sunday morning had dawned to a frigid Minnesota northwest howler. The next Sunday was better, though, and a great crowd stood waiting when the borrowed Army truck arrived with sandbags, ground cloth (actually a large remnant of a stratosphere balloon my mother had piloted in 1934), and hydrogen cylinders. Our magnificent ground crew, none of which, except the Piccards and Ralph Upson, had ever seen a balloon before, and the giant paper bag itself followed.

Upson took me aside and reassured me that the balloon was safe. He had done the calculations and he figured that the Japanese paper had a 50-to-1 safety factor. Not bad for an old, used, patched, $220 device. I felt a lot better, but the low overcast was worrying me. I had

Some last-minute repairs readied the balloon (above) for the two-hour flight, which drew media attention and big crowds (opposite).

planned to just let the balloon rise up to its natural ceiling, float for the minimum federal requirement, and then risk one crash on the frozen tundra. But it was not to be: I was going to have to actually fly the thing, working hard to control ballast and gas flow in order to maintain altitude.

After a flawless takeoff, with only a half a bag of sand baptizing a poor spectator's fine fur hat, I cleared the Foshay Tower and headed for the cloud base. You can't see the Foshay Tower today, as it is hidden by the newer buildings, but at the time it scared me—it was all I could see. Next the cloud base threatened. I did have an Army Air Forces Twin Beech escorting me to keep airplanes with rubbernecking pilots away, but he wouldn't be able to help if I let my craft seek its own level in the overcast. So alternately valving gas and dropping sand—which always flew back in my face—I worked my way across the concrete chasms and cliffs. (Fifty years later, Bertrand Piccard and Brian Jones used a long plastic sleeve to drop ballast from the Breitling Orbiter III on its global flight, solving the sand problem.)

I had never flown a paper balloon before. I had never flown with hydrogen before. Nor had I ever flown with an overcast sky, or in a balloon without a net. I had never flown alone before, but it was heavenly. I had more sand than I could possibly need. There were no thermals to disturb the absolute dream of pure flight. I was cozy in my fur-lined flightsuit (also a captured Japanese war souvenir, worn in honor of the balloon's own heritage). All I had to do was learn how to fly. Hydrogen expands differently from helium, but the flying went surprisingly well and soon I was over open country.

I came down low and rode on the automatic buoyancy-equalizing effect of a drag rope: The balloon descends until the rope begins to touch the ground, which, in turn, relieves the balloon of the weight of the rope and it stops descending. Crewman Ben Minnich grabbed it and got a free ride at windspeed across a frozen lake. I hit a row of poplars, he let go, and I swooped up and over to greet my first high-tension powerline. I cleared the wires handily, but the photographs show that I was below the level of the steel towers on either side of my path.

Then I had a long drive straight down a country road. Imagine someone coming the other way and meeting my escort of crewmen and spectators coming three abreast up the two-lane road. They fanned out through the town of White Bear Lake at a 45-degree angle to the street grid. Some cut across vacant lots, some did worse. The police stopped the army truck and threatened to lock the people inside up for causing it all. I wondered why they hadn't been warned of our project.

My crew extracted themselves from the White Bear police department and actually had my ground cloth ready for the deflation when I landed—after a quarter-mile drag across the frozen furrows. It was like driving down railroad tracks in that aluminum basket. All the reporters were there too. The St. Paul reporters got there, but late, after all the others had gone. They did, however, get the best picture: the happy pilot sitting under a tree stuffing angel food cake into his broad victory grin. My father always carried angel food cake on balloon flights—you never know when you might need it—and had baked one especially for my solo. The press all reported on "the Piccard Flight" and the *Daily Times* reported on "The *Daily Times* Flight." The competing press had morning editions, but the *Times* was an afternoon paper, so we got scooped by everyone else.

I never flew old Fu-Go again. The FAA refused to issue a registration certificate for her, as I had no bill of sale from the manufacturer. I got my free balloon certificate, though—as well as the distinct thrill of putting a sinister and silent wartime weapon to a slightly more peaceful use.

SIGHTINGS

"A clear day is a boring day," says photographer Paul Bowen, who has made a career of photographing airplanes in flight. Though his backdrops vary from cityscapes to coastal islands, he has a particular fondness for clouds. "They're wonderful design elements, and they're always different," he says.

These images, taken from his new book, *Air to Air, Volume II* (North Shore Press, 800-697-2580), were captured between planned shots or while in transit, and they offer a glimpse of what pilots are lucky enough to fly through. "It's a bonus to the thrill of flying," he says.

Bowen usually schedules his flights for first and last light, and always checks weather reports for potentially interesting cloud formations. He works from the back of a B-25 bomber with its tail cone removed. Though there's no glass to intrude between cloud and camera, he understands that other fliers who want to capture their own in-flight images might have a window to contend with. His advice is to minimize reflections from inside the cabin by placing the camera close to the window. Other pointers: Use a fast shutter speed to reduce the effects of vibration and turbulence, try filters to emphasize colors, and—above all—don't use flash!

Jet Set

The History of North American Small Gas Turbine Engines

by Richard A. Leyes II and William A. Fleming. National Air and Space Museum/American Institute of Aeronautics and Astronautics (800-639-2422), 2001. 998 pp., $44.95 (hardbound).

PAUL BOWEN

The development of small gas turbine engines made an entire family of turboprop-powered commuter airliners and business aircraft like the Beech King Air possible.

Engines propel aircraft and the aircraft industry. The development of a wholly new—not evolutionary or derivative but completely new—engine design is a rare event, mainly because of the enormous investment required. Airplane makers rely on engine builders for the incremental gains in performance and efficiency we call "progress." Every new generation of airliners and military aircraft is defined by a new engine family. This book teaches us that a series of small gas turbine engines was responsible for creating an entire segment of aviation.

Reference works about engines are as rare as new engines are, at least in part because they represent so much hard work. Former National Air and Space Museum curator Rick Leyes and his co-author, William Fleming, now deceased, spent years interviewing engineers, executives, and officials of government and industry to assemble the narrative history in this satisfyingly chubby volume. Combined with their work poring through documents and archives, the result is the only definitive story of a unique aeronautical niche.

Small gas turbines power the regional airliners, business aircraft, helicopters, and personal airplanes that make up the overwhelming majority of the world's aircraft fleets. Think of these powerplants as the prime movers of aviation—they move more people and goods than any other segment. From the nearly ubiquitous and enduring United Aircraft of Canada (Pratt & Whitney) PT-6A family of turboprops and turboshafts to the numerous examples of "expendables"—engines that were designed to power missiles and whose service lives are measured in the tens of hours, the authors take the reader from the roots of development to the final performance of the fully mature engine in the marketplace.

The book is organized into four sections: an introduction to instruct the reader in the boundaries of this segment of the propulsion industry—what these engines are and what they aren't; individual chapters devoted to the leading manufacturers, in which the histories of engine families are affectionately portrayed; an analytical look at the industry's evolution in more general terms; and finally, a series of charts and tables of data.

For propulsion engineers, this book is a must-have. What's surprising is that the engine histories have a broader appeal and readability that will satisfy the non-professional's itch for hidden lore ("Oh, so that's why they did it that way…").

For anyone who grew up around airplanes during the boom that began in the 1950s and lasted through the early 1980s, the characters in this drama—engineers like Garrett's Ivan Speer and GE's Sanford Moss—make this book a kind of family album; it's an industrial memoir. They say engine people are different, that anyone who can stare at a Pratt for hours is a little barmy. Maybe. But as this book points out, engines are milestones that mark our progress, and it's hard to keep from looking out the window as you travel down the road.
—George C. Larson is the editor of Air & Space/Smithsonian.

Horses Don't Fly

by Frederick Libby. Arcade Publishing, 2000. 274 pp., $24.95 (hardbound).

This is a delightful yarn about a boy in the early years of the 20th century, who started out breaking horses and punching cows from

Colorado to California. At 20, Fred Libby decided to try his luck in South America, but the next boat happened to be going north. After losing his grubstake in an oil well fraud, Libby joined the Canadian army's Motor Transport, undaunted by the fact that he didn't know how to drive.

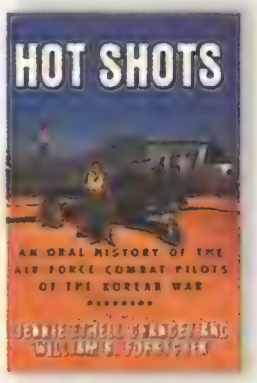
On the Western Front in World War I, wrangling a truck proved to be wetter work than he'd bargained for, so when the British Royal Flying Corps (predecessor to the Royal Air Force) advertised for "observers," Libby signed on. He soon learned that his actual job was to man the forward gun in a Farman F.E.2b fighter—and the rear gun also, by standing up, facing about, and shooting over the wing. "This doesn't seem possible," he says of his briefing by the squadron commander. "I left my base at seven-thirty, it is now ten-thirty, and if [the major's] orders work out, hell, I could well be dead by noon."

Instead, he downed a German fighter on his first flight over "Hun Land." Nine more victories followed, earning him a commission and a medal from King George. He then became a pilot—as you might expect, soloing on his first day—and brought his kills to 14 before the United States entered the war. He returned home to join the infant Aviation Section that was America's first response to the air age. (He especially disliked the Army's required uniforms, much preferring the work of his bespoke tailor in London.) Perhaps fortunately, Libby never flew in combat for the U.S. Army, but rode out the war as a victim of the great influenza epidemic.

There are photos of the author as cowboy, truck driver, and British officer; an introduction and footnotes by the novelist Winston Groom; and an afterword by Libby's granddaughter, who sounds every bit as charming as he was.
—Daniel Ford is the author of Remains *(a story of the Flying Tigers).*

Hot Shots: An Oral History of the Air Force Combat Pilots in the Korean War

edited by Jennie Ethell Chancey and William F. Forstchen. William Morrow, 2000, 240 pp., $25.00.



Hot Shots chronicles the experiences of a half-dozen U.S. fighter aces—men who flew the F-86 Sabrejet and venerable P/F-51 Mustang in Korea—in their own voices. The tales range from humdrum to poignant to hair-raising, and illustrate the dramas and hazards of the three-year, U.S.-led police action and the uncertainty of the outcomes.

Consider: Five months into the war, two U.S. Marine divisions were surrounded by Chinese troops and had to be evacuated by sea. Seoul was lost and retaken four times. U.S. pilots might not engage enemy pilots for weeks, then engaged hundreds all at once. The Yanks faced an unpredictable enemy flying worthy aircraft—the MiG-15 could outrun and outclimb the famed F-86 Sabre. Many tactics, the pilots concede, were invented on the spot. "Top Gun" schools didn't exist. Complicating matters was the U.N. command's exasperating order not to chase Chinese pilots to their Manchurian havens. And the appearance of Russian pilots flying with the North Koreans—a fact suspected but not confirmed until 1991—added to the excitement.

The style of *Hot Shots* is afterburner-quick, the idiom typical of fighter pilots: detailed, yet spare and on point. Unsurprisingly, the combat tales are the most gripping, such as that of World War II veteran Colonel Cecil Foster of the 51st Fighter Interceptor Group, who survived one 45-minute engagement—possibly the war's longest—against 10-to-one odds. Somehow, jet novice Foster also managed to make his first kill.

Another 51st pilot, double ace (10 kills) Colonel Harold Fischer, recounts war's tragic face. After "lighting up" a MiG, Fischer flew alongside and saw that the Korean pilot was clearly unable to eject from his smoke-filled cockpit. Fischer fired his guns again to end the pilot's misery. Fischer's account of his own long imprisonment and near death in Chinese captivity is harrowing.

Forstchen and Chancey (daughter of the late warbird pilot and aviation writer Jeff Ethell) sandwich the stories with their own commentary. They detail the aircraft and tactics involved, tally losses, and provide easily digested historical and geopolitical overviews.

A quick but filling read, *Hot Shots* will satisfy on many levels.
—David Walsh is a freelance writer and photographer who specializes in aviation.

PILOT'S GUIDE

Fly the Big Sky! A Pilot's Guide to Montana's Prairie Towns and Mountain Hideaways

by Galen L. Hanselman. Q.E.I. Publishing (800-574-9702), 2000. 720 pp., $49.95 (Spiralbound).

An entertaining mix of backwoods yarns and practical advice, Hanselman's guide details Montana history and local hangouts. Diagrams for 76 airstrips and a color photo of each are included. And the descriptions don't exactly describe an approach to JFK. A sample: "No fuel, no lights, no repairs, no phone… Use caution for livestock, wildlife, gopher holes."

Spitfires Over Sicily: The Crucial Role of the Malta Spitfires in the Battle of Sicily, January–August 1943

by Brian Cull with Nicola Malizia and Frederick Galea. Grub Street, 2000. 234 pp., $29.95 (hardbound).

Spitfires Over Sicily picks up where Brian Cull's previous studies of the Mediterranean air war, including *Malta: the Spitfire Year 1942*, left off. The RAF's successful defense of Malta gave the Allies control of the sea lanes to North Africa, resulting in the once vaunted German Afrika Korps withering

GIRL POWER

Cool Careers for Girls in Air and Space

by Ceel Pasternak and Linda Thornburg. Impact Publications (800-361-1055), 2001. 118 pp., $19.95 (hardbound).

A mix of female astronauts, engineers, airline pilots, and technicians spell out what it takes to follow their lead into the left seat or into space.

in the face of U.S. and British offensives.

By the start of 1943, when Cull begins his narrative, the tide had only just begun to turn for the Allies in the skies over the Mediterranean. However, in the eight months covered by Cull, Spitfires and other Malta-based fighters established air superiority over outnumbered and technically inferior Axis air forces. The Spitfire Vs that had served Mediterranean units in early 1943 were initially hard-pressed to fight it out with the superior Me 109Gs, but by the invasion of Sicily in July, the Allies had a qualitative as well as quantitative advantage with the introduction of the much-improved Spitfire IX.

While many aircraft types figured prominently in the battle for Sicily, the Spitfire's dominant role deserves the special attention that Cull has lavished on it. Cull uses brief first-person accounts, sprinkled liberally throughout his narrative, to bring the reader into the action. The approach works well, and keeps the multitude of units and personalities distinct. While the RAF and its Spitfires are given the limelight, Cull does not ignore the contributions of other aircraft types and nationalities. The U.S. Army Air Forces, Canada, Australia, New Zealand, and South Africa also fielded Spitfire squadrons during the operation and are given ample coverage. The air battles fought over Sicily established the superiority of the Allies once and for all, and Cull's work ensures that the pilots responsible receive recognition.

—Roger Connor is a museum specialist in the division of aeronautics at the National Air and Space Museum.

THE PLANETS

Destiny or Chance: Our Solar System and its Place in the Cosmos

by Stuart Ross Taylor. Cambridge University Press, 2000. 229 pp., $14.95 (paperback).

This book provides an easy-to-understand guide to some of the recent discoveries that astronomers have made about the formation of the solar system and the geology of the planets.

CREDITS

Stealing the Show. Douglas Hinton flew jet fighters in the Royal Canadian Air Force. He later went on to hold marketing positions with Beech Aircraft, Learjet, and Lake Aircraft. He lives in Florida.

When Bad Things Happen to Good Drones. O.H. Billmann liked working with drones, since he was always one himself.

The Fastest Show on Earth. Carl Hoffman is the author of *Hunting Warbirds: The Obsessive Quest for the Lost Aircraft of World War II*, published by Ballantine Books in April.

A licensed pilot, Tim Wright blends his love of aviation and photography into what he considers "the ultimate career."

Starfighter. John MacNeill is a freelance artist whose illustrations appear frequently in *Air & Space/Smithsonian.*

Hill Climb. Donald Sherman is a Michigan-based writer who concentrates on motor-related subjects for *Automobile, Popular Science*, and other publications.

High Honor. Daniel Ford writes frequently about aviation history.

Restoration: Grand Dame. John Sotham is an associate editor at *Air & Space.*

Mark Godfrey holds a commercial pilot's license with a glider rating, and he prefers to spend summer evenings in any tail-dragger at least as old as he is.

Q. Eric Adams, who often thinks he's James Bond, is actually an associate editor at *Air & Space.*

Predator: First Watch. Linda Shiner is the executive editor of *Air & Space.*

For this story, contributing editor Chad Slattery visited air bases in California, Nevada, and Bosnia-Herzegovina. His images are on the Web at aeropix.com.

Fishing for Saint-Ex. Joseph Harriss is an American journalist based in Paris.

Particle Man. Andrew Lawler is the Boston correspondent for *Science.*

One Balloon Bomber (Slightly Used). After flying Fu-Go in 1947, Don Piccard organized the first balloon club in the United States. In 1963 Piccard and fellow balloonist Ed Yost made the first crossing of the English Channel in a hot-air balloon.

CALENDAR

April 7
Seminar on the Grumman Aircraft Corporation: "Grumman Ironworks." Planes of Fame Museum, Chino, CA, (909) 597-3722.

April 9–12
National Space Symposium: "Space 2001—An Earth Odyssey." Broadmoor Hotel, Colorado Springs, CO, (800) 691-4000.

April 27 & 28
Spirit of Flight Airshow and Aircraft Walkabout. Lone Star Flight Museum, Galveston International Airport, Scholes Field, Galveston, TX, (409) 740-7722.

May 1–3
Reunion: 22nd Military Airlift Squadron. Wright Patterson Air Force Base, OH, (937) 323-6304.

May 2
New Jersey State Aviation Conference: "New Jersey's Airports in the 21st Century—'It's More Than Pavement.' " Officers' Club, McGuire Air Force Base, NJ, (609) 530-2900.

May 4–6
17th Annual Symposium of the Society of Air Racing Historians. Radisson Hotel-Southwest, Cleveland, OH, (440) 255-8100.

"Barona Casino Wings Over Gillespie": World War II Static Airshow. Gillespie Field, El Cajon, CA, (619) 561-3100.

Georgia Wings Weekend and Fly-In Pancake Breakfast. Sport Aviation Center, Lawrenceville, GA, (770) 613-9501, www.wingsweekend.com.

May 6–12
Great Southern Air Race. Cross-country 1,100-nautical-mile race sponsored by the Florida Race Pilots Association, (904) 325-3175.

International Aerospace Exhibition. Southern section of Berlin-Schonefeld Airport, Germany, phone 49 (0) 30-2061.

May 10–13
Reunion: 446th Bomb Group, 8th Air Force, World War II. New Orleans, LA, (714) 832-2829.

May 19
Majors Field Fly-In, Greenville, TX, (903) 455-8170.

June 1 & 2
15th Annual Biplane Expo. Frank Phillips Field, Bartlesville, OK, (918) 622-8400.

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *750 9th St. NW, 7th Floor, Washington, DC 20001. Events will be listed as space allows.*

ON THE WEB SITE

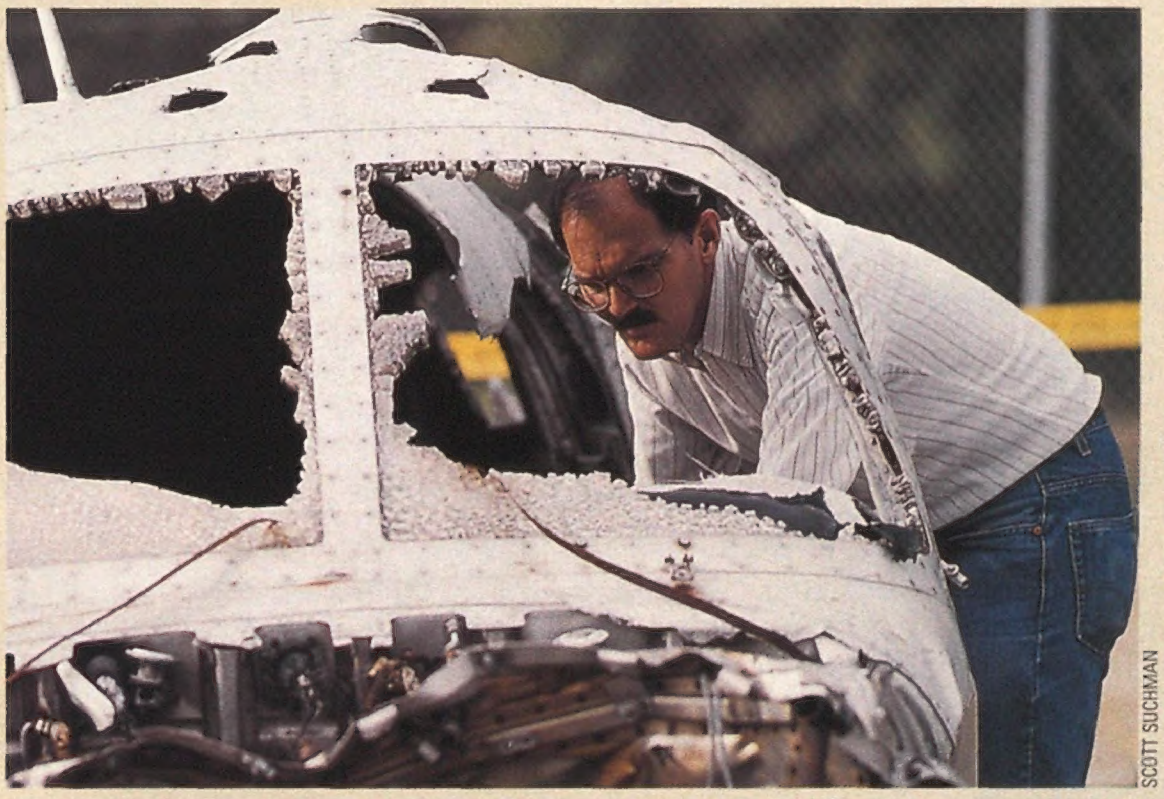
www.airspacemag.com

COURTESY PIONEER/UAV INC

The Un-Aircraft

You may know that the Navy's Pioneer has become the first unmanned aerial vehicle to be donated to the National Air and Space Museum. And that last May the Air Force's Global Hawk flew a non-stop, unescorted, unrefueled round trip between Florida and Portugal. But did you know that B-17s were flown remotely during World War II? For other facts about U.S. UAVs, visit our Web site.

FORECAST



SCOTT SUCHMAN

A student in the classroom at the Transportation Safety Institute.

In the Wings...

Crash Course

Aircraft crash investigators study the subtleties of cause and effect at Oklahoma City's Transportation Safety Institute.

The Mother of All Motherships

NASA's B-52B, tail number 008, has taken hundreds of aircraft under its wing.

Flying the LEM

They were among the best pilots in the world, but even the Apollo astronauts feared the Lunar Excursion Module.

The Day the Station Fell

It was launched in 1986, was home to 104 space travelers, and became the crowning achievement of a nation's program of space exploration. How will Russians say goodbye to Mir?

A Flying Vietnam Memorial

At several aviation events around the country, a restored Sikorsky UH-34D Seahorse, the type that delivered many a Marine to battle in Vietnam, is now delivering memories of the war.

Canadian Club

Of the 37,000 missions flown by Great Britain's four-engine Halifax bombers, 29,000 were flown by Canadian crews. Today, a Canadian Airlines captain and a former Halifax pilot are restoring one of the old bombers for display in the Royal Canadian Armed Forces Museum in Trenton, Ontario.

Lift for Labor

Would Ohio's 1937 "Little Steel Strike" have struck had the effort not been supplied by a fleet of light aircraft?

Proteus Maximus

Last October, Scaled Composites pilots Mike Melville and Bob Waldmiller took off from the civilian flight test center at California's Mojave airport in the twin-jet Proteus and set three altitude records, reaching 63,245 feet, maintaining horizontal flight at 62,385 feet, and carrying a 2,200-pound payload to 55,994 feet, all of which were recently certified by the National Aeronautic Association.

Powered by two Williams International FJ44-2E turbofans, Proteus is a HALO aircraft—high altitude, long operation—designed to carry 2,000-pound payloads to 60,000 feet and loiter there for hours. Potential missions include reconnaissance, atmospheric research, commercial imaging, and, ultimately, serving as a launch platform for a three-passenger spacecraft (Proteus designer Burt Rutan is a contender for the $10 million X-Prize being offered to the first entrepreneur to launch a piloted three-place spacecraft to 62 miles and repeat the flight within two weeks.)

SCALED COMPOSITES INC.

Proteus is initially being marketed as an atmospheric communications satellite, one that will fly wide circles high over cities for 14 hours at a stretch, carrying an 18-foot-diameter antenna and providing coverage for an area of 60 miles. Scaled Composites is marketing both a two-person crew and an unmanned version. Crew positions will target young pilots who want to build up their time.

Scaled Composites conducted the record flights under sponsorship of the NASA Office of Earth Science with funding from the National Oceanic and Atmospheric Administration, the Department of Defense, and NASA. The NAA certified the records in Class C-1.e, Group III, land-based airplanes with jet engines, weighing from 6,614 to 13,228 pounds. Takeoff weights were 8,962 pounds and, with the payload, 11,319 pounds. The previous altitude and horizontal flight records, 54,570 feet, were set by a Lear 28 in 1988.

Proteus made its first flight in late 1998. Its modular construction and extendable wings can be adapted to carry a variety of payloads, hence the name—Proteus is the mythological Greek shepherd of the seas who can assume different shapes at will.

Scaled Composites was founded in 1982 by prolific designer Burt Rutan, who *Time* magazine called "one of the country's most innovative designers." The company has produced more than 30 unique aircraft, including *Voyager*, which in 1986 flew around the world non-stop without refueling, earning the NAA Collier Trophy.

—Charles Spence

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa-usa.org or call (703) 527-0226.

LOGBOOK

Awards

NASA's Spacelink Team received the Brewer Award for aerospace education last March for its contribution to the educational community by pioneering electronic access to NASA's aeronautic- and space-related information. In 1988, before the World Wide Web existed, Spacelink became NASA's first electronic bulletin board service, and has provided quick and easy access for 7.5 million educators and students.

Call for Nominations

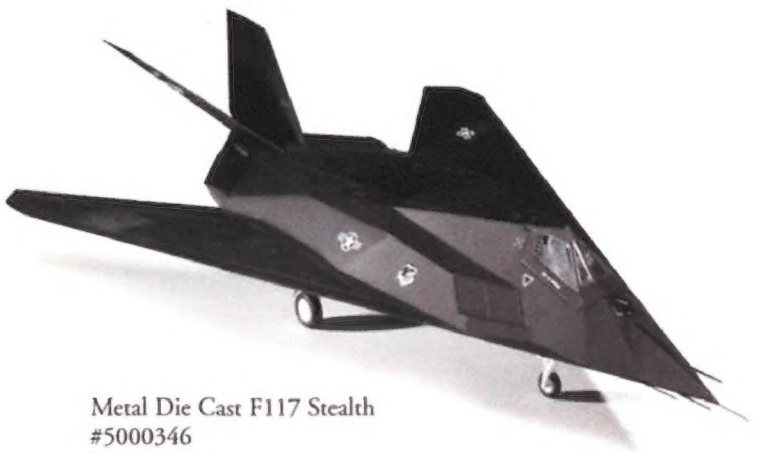
Nominations are open for the NAA Elder Statesman, Henderson, and Stinson Awards through June 30. Elder Statesman nominees must be at least 60 years old and U.S. citizens who have made significant contributions to aeronautics for at least 15 years. The National Aviation Club Cliff Henderson Award of Achievement is made to a living individual or group whose vision has made a contribution to the advancement of aviation or space activity. The NAC Katherine and Marjorie Stinson Award honors a living woman for an enduring contribution, a meritorious flight, or a technical development in aeronautics or space sciences. For additional information, contact Ann Ruebelmann, (703) 351-2462 or e-mail: aruebelmann@naa-usa.org.

Records

Memorable records set last year include a 348-mile flight in a hang glider, an altitude of 17,671 feet in a powered parachute, and an 8-hour, 10-minute flight from Tokyo to Los Angeles in a Boeing 747-400.

Events

Some 5,000 athletes from 80 nations will participate in the Second World Air Games in Andalucia, Spain, from June 14 to July 1. Competitions include hang gliding, soaring, aerobatics, air rallies, microlights, skydiving, gas and hot-air ballooning, and airships. Contact the World Air Games office in Madrid at 34-91-508-2950, or visit www.wag2001.org.



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